NEW ENGLAND WATER WORKS ASSOCIATION.

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DRIVEN WELLS AT BROOKLINE, MASS.

BY F. F. FORBES, C. E., SUPERINTENDENT.

[*Read June* 11, 1896.]

The material for this paper was gathered from work which was done under my direction in Brookline, two and four years ago, to increase the water supply of this town.

The work consisted in laying a suction main made up as follows: 2,054 feet of 24-inch pipe, 2,093 feet of 20-inch pipe, 531 feet of 16-inch pipe, 1,427 feet of 10-inch pipe, and 155 feet of 8-inch pipe. A total of 6,260 feet, and driving 201 two and one-half inch wells, and connecting 160 wells; the other 41 wells were failures.

The plant was designed to deliver water at the rate of 5,000,000 gallons per day for as many hours each day as might be necessary to supply the town. A slight study for such a plant will convince one that it is very important that the pipes and connections should be air tight, and so put together that they will remain in this state even if some small settling should take place in the suction main; for not only does it cost money to pump air from which no benefit is received, but its presence in the conducting pipes lessens the amount of water they will carry, also decreases the quantity which can be taken from the ground by partially destroying the vacuum, and also causes the pumps to perform badly unless the air is removed before it reaches them.

It is not an easy matter to lay a long line of pipe, drive and connect numerous wells, and leave no place through which the air can flow. Not only must the material used be without defects, but the work must be most faithfully done — the latter being by far the most difficult part. It is with much satisfaction that I can speak of the results obtained in Brookline. The plant has now been in use nearly two years without giving the least trouble from air leaks, or in fact, from any other causes.

A description of the principal details of construction is as follows: the 24-inch suction main is connected directly to the pumps without an air separator, or sand receiver. The top of this main is laid from six to eight feet below the surface of the ground, and about five feet below the usual level of Charles River during the summer months. The main was laid at this depth for two reasons: first, that more water might be drawn from the ground, and second, that the main might be in the most favorable position, not to be affected by expansion or contraction due to changes of temperature. The main has a slight pitch from the pump, the further end being about six inches lower. This construction is necessary to allow any air which may be in the pipes to flow towards the station and not pocket at any point on the line.

This suction main is composed of ordinary cast iron bell and spigot pipes, laid in the usual way with lead joints. Extra pains were taken, however, in caulking these joints. During the laying of this main and the connecting of the wells, it was necessary to keep a six-inch rotary pump running day and night to free the trench from water. The bottom of the trench was a rather fine sand, and the pipe was supported on a blocking reaching to a timber platform, placed about eight inches below the bottom of the pipes, to allow room to caulk the joints.

Short cast-iron Y branches of special design were placed in the main for each well. The two and one half inch outlets of these Y branches were drilled and tapped to a templet at the foundry before tarring, under the watch of an inspector.

The wells were connected to these Y branches by two lead connections, two and one half inches in diameter and of a weight of eleven pounds per foot. A gate with companion flanges was placed between these lead connections — the flanges forming the union joint between the wells and suction main. The soldering nipples used

with the lead connections were made to order and of the best steam metal. They were delivered untinned in order that any defect in them could be easily found. Special care was taken to solder these nipples to the lead connections. A wiped joint was not considered to be always air tight, and of this size, rather difficult to make, and we finally decided to sweat the nipples in, as this process is sometimes called. The necessary heat was obtained from cast-iron plugs heated in a portable forge which fitted loosely into the nipples. The well pipes were screwed together with special wrought-iron couplings until the ends butted, and special cement was used on the threads. The wells were from thirty-five to ninety-five feet deep. Two and one half inch tees of a special pattern were placed on the wells at a proper grade to allow them to be connected by means of the lead connections to the suction main. The piping of the wells was carried to the height of about one foot above the surface of the ground and capped with a special cap. The wells have open ends, no strainers of any kind being used. In the bottom pieces, there are five rows of holes with nine holes in a row, spaced two and one half inches apart from centres, and bushed with three-eighths inch brass pipe.

As before stated, we have had no air leaks so far, and as the suction pipe is laid with lead joints, and the connection between this pipe and the wells made with lead pipe, thus making the whole construction flexible, we can see no reason why air leaks should ever occur.

The detail of the cost of construction of the work done two years ago, which included laying all of the 20, 16, 10, and 8 inch pipe, and driving 159 wells, is as follows: —

1st. The cost of driving and connecting 118 good wells, and driving and pulling up 41 poor wells: —

Cost of labor, driving wells	$1,561 00
Cost of labor, connecting wells	210 00
Cost of labor, pumping out wells	369 00
Cost of the well pipes, not including the bottom piece	572 06
Cost of the bottom piece	196 23
Cost of preparing the bottom pieces	118 00
Cost of the gate tops for the wells	360 37
Cost of the gates	660 80
Amount carried forward	$4,047 46

Amount brought forward	$4,047 46
Cost of two and a half inch tees	94 40
Cost of soldering nipples	250 16
Cost of solder	23 00
Cost of three quarter inch rope	5 31
Cost of oil	6 25
Cost of red and white lead	23 59
Cost of lead pipe	333 40
Cost of making lead connections in the shop	52 50
Cost of two and one half inch plugs	2 29
Cost of two and one half inch couplings	155 40
Cost of pulling up poor wells	80 00
Cost of Akron pipe for gate boxes	306 92
Cutting threads on pipe	206 72
Teaming	14 00
Miscellaneous	51 26
Total cost of the wells	$5,652 66
Number of feet of good wells driven	5,977
Number of feet of poor wells driven	1,741
Total	7,718
The average depth of the wells	50 feet
Average number of feet driven per day with gang of four men,	50 "
Cost of labor, driving wells per foot	$0 21
Average cost of each good well, including driving and connecting, and expense of driving and pulling the poor wells	$47 90

The detail of the cost of laying the suction main: —

Cost of labor	$10,428 32
Cost of lumber	1,118 55
Cost of the pipes	6,248 07
Cost of the gates	341 16
Cost of lead	515 09
Cost of pumping, the engineer	458 56
Cost of pumping, coal	174 71
Cost of unloading pipes	39 00
Cost of inspecting pipes at foundry and at the cars	183 00
Cost of rubber boots	210 00
Cost of shovels	52 00
Cost of carting men to and from work	947 30
Cost of hauling the pipe from the cars	300 00
Cost of miscellaneous expressing	79 30
Cost of oil for the engine	4 80
Cost of jute packing	12 74
Miscellaneous	155 43
Total cost of laying the pipe	$21,268 03

The amounts laid are as follows: —

20 inch pipe	. . . . .	2,023 feet
16 "	. . . . .	551 "
10 "	. . . . .	1,420 "
8 "	. . . . .	155 "
		4,149 feet

The total cost of laying the pipe	$21,268 03
The total cost of driving and connecting the wells . . .	5,652 66
Total cost	$26,920 69
The total cost of laying the pipe, driving and connecting wells, per foot of suction main	$6 45

DISCUSSION.

Mr. HAWES. I would like to ask Mr. Forbes what kind of wrought-iron pipe he used for the wells.

Mr. FORBES. I used ordinary wrought-iron pipe. The bottom piece is extra heavy, with no coating at all; the idea being that if the well should stop up with rust, the gate can be shut, the cap removed, and the well drilled out. The connection between the well and the main is lead. We don't expect they will fill up, but it is easy to test the wells at any time and remove any rust which may be in them.

The PRESIDENT. Won't you describe the method pursued in getting rid of the rust? Do you mean you take off the cap and bore down through?

Mr. FORBES. All our wells are driven with open ends, and the holes in the bottom piece are bushed with a three-eighths inch brass pipe.

Mr. FULLER. If I remember rightly, Mr. Forbes has described at one of our meetings a method of cleaning out a well which had been driven some time.

Mr. FORBES. If the fine sand accumulates in the bottom of the well and gets above the bottom piece, of course no water can enter; and if you run a drill down in the usual way with a jet you are sure to throw most of that sand off into the ground, and it may come back later and fill up again. So I have a tool I lower down in the well, simply a jet like a water jet, only reversed (that is to say, water is pumped out of the pipe instead of into it), which screws on to the end of an inch pipe, the smallest opening being at the bottom,

so anything which gets into the pipe is sure to come through it. If a stone is small enough to get into the opening it will go through the pipe. This is lowered into the well and all the sand and material is pumped up. It is a steel pointed tool and we can churn it up and down and break up the stones.

A MEMBER. How would that work in the case of a well ninety-five feet in depth.

The PRESIDENT. The water line is near the surface of the ground, isn't it?

Mr. FORBES. If the water line is within twenty feet of the surface of the ground it would work just as well; it is a question of the difference of head.

Mr. SMITH. Did I understand that all of this suction main was laid below the level of the ground water?

Mr. FORBES. The normal level of the ground water is about five feet above the top of this main, but when we begin to pump, of course, the water goes down, so the whole length of the main is entirely above the water in the ground. When we start pumping in the morning at the present time the pipe is covered with water; as we pump the water goes down until the whole pipe is above the water line.

The PRESIDENT. You begin to draw from your reservoir, in other words?

Mr. FORBES. Yes; the water goes down into the ground. The suction main is a mile and a quarter long, and the water goes below the pipe. We have no air to pump and we have no air.

The PRESIDENT. It fills up again during the night?

Mr. FORBES. It fills up again during the night.

Mr. WHITNEY. I would like to ask Mr. Forbes why he found it advisable to use plain pipe for his wells, rather than a protected pipe like galvanized iron, which probably would not fill up so quickly with rust?

Mr. FORBES. We thought in driving the well and drilling it out while it was being driven, the tools used would be apt to injure the coating to quite an extent. And then we have found that our water has a bad effect on galvanized pipe. So we use plain pipe; and if it ever does rust all we have to do is to shut the gate, remove the cap and run the tool up and down. Probably before the pipe rusts up, it will have to be pumped any way, for wells fill up more or less.

Mr. WHITNEY. I wanted to bring out that point with reference to the difference between the two waters. We have apparently the same water in Newton that they have in Brookline, and yet for our use in Newton, galvanizing has been found to be the only successful protective coating for iron pipe, and that has been a perfect success. Service pipes which have been in from fifteen to eighteen years show no signs whatever of deterioration, and no reason why they should not last for the next fifty years.

Mr. FORBES. We cut a long thread on the bottom of our pipe, and run the coupling clear up so it is flush with the end of the pipe, that is, it is not run on half way, as is usual, but it is run entirely over the bottom of the pipe. The bottom of the pipe is strengthened by the coupling. We use cement-lined service pipes, and have, entirely, for the last ten or fifteen years. We have taken out cement-lined pipe that have been in use since the works started, twenty years ago, and you can look through them and see no indication of rust.

Mr. HYDE. Have you ever used galvanized pipe?

Mr. FORBES. We used it a little a good many years ago.

Mr. HYDE. What was the result?

Mr. FORBES. It filled right up, worse than plain pipe.

Mr. HYDE. It seems to me very strange that the difference in water taken from points so near together as Brookline and Newton should be so great. We have used a number of kinds of pipe, ordinary iron, enamelled iron, and about everything else, with the exception of cement pipe, and we find in Newton that galvanized iron pipe is the best we can use. Of course we use lead pipe to some extent, but for iron pipe galvanized iron pipe has served us the best.

The PRESIDENT. Have you ever made any chemical test to see whether there is any trace of zinc in the water, after passing through the pipe?

Mr. HYDE. Yes, sir; I had some tests made a short time ago, and found it had not affected the water; there was no appreciable amount of zinc in it.

The PRESIDENT. I have had one of those cement-lined wrought-iron pipes, Mr. Forbes speaks of, in my house in Brookline, ever since the beginning of the works, and it is in very good condition to-day.

THE FURTHER WATER SUPPLY OF THE CITY OF NEW BEDFORD, NOW BEING CONSTRUCTED.

ADDRESS BY MR. EDMUND WOOD.

[*January* 13, 1897.]

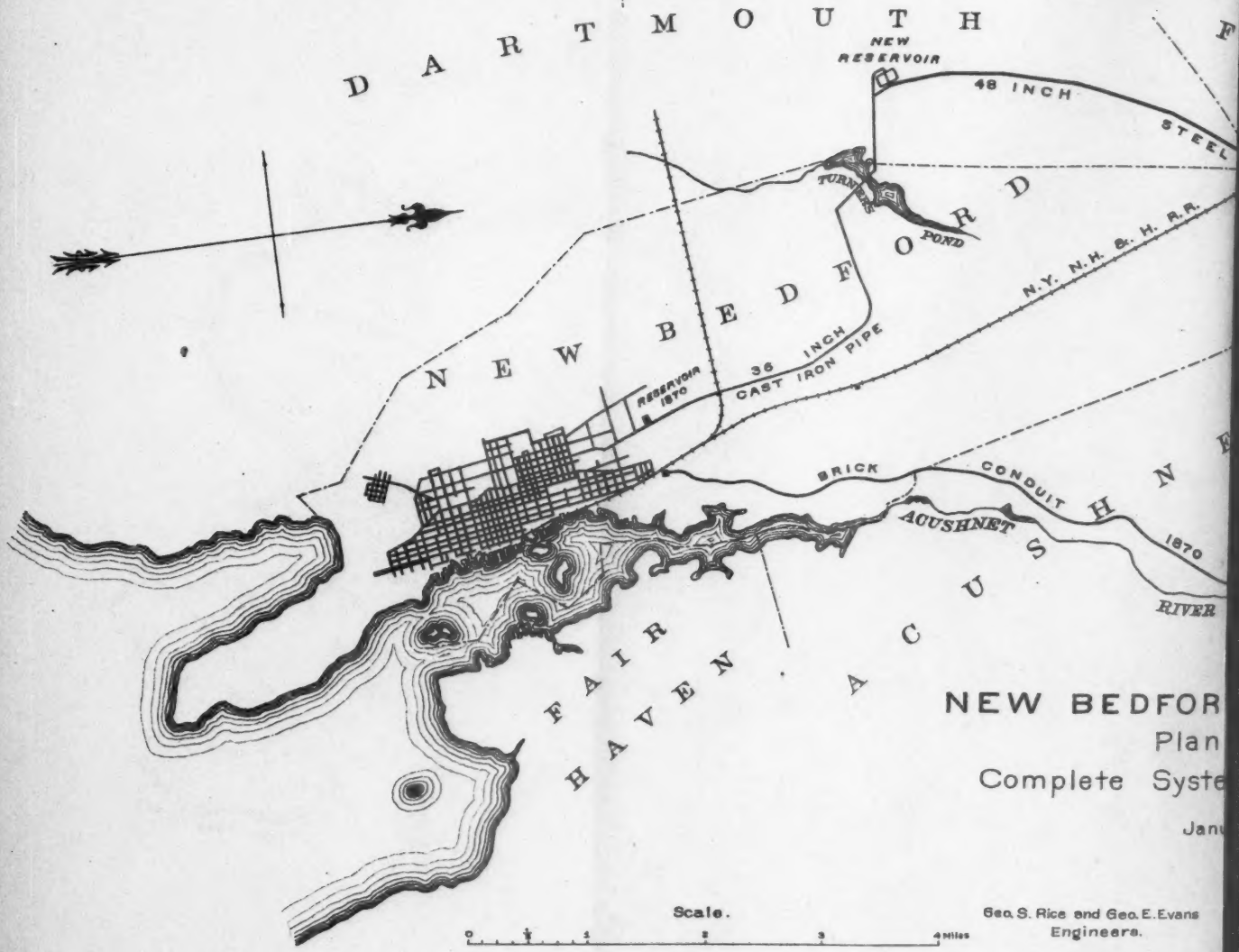
Mr. President, and members of the New England Water Works Association:

The city of New Bedford is very glad to share its recent experiences with you. They have all been new, of great interest and full of excitement to a Water Board of laymen. But in describing them to you, I must remember that you are all experts; you have all probably had your own experiences with Water Works Construction and much of it has become an old story.

I shall endeavor, therefore, to give a very rapid review of the work, dwelling only upon those things which may be of more especial interest, which are in some respects unique, or which, at least, are not common to all systems of water works. You all probably have heard of New Bedford. Our local pride leads us to hope that also you know where it is. May be the fact that this association has so long had the services of New Bedford's efficient Water Works Superintendent, Mr. R. C. P. Coggeshall, has given that town a little notoriety among you. It is of this city and its work that I shall now speak. In doing so, it might be well to describe the present system of the works, and then pass on to the changes which have been made and are being made.

Our Water Works were built very soon after the war. They were built for a maximum capacity of five million gallons. A storing reservoir was constructed near the head waters of the Acushnet River by building a dam across the valley. The bottom of this reservoir is covered with peat, leaves, and all the remains of vegetable growth. And this it is which is responsible for that beautiful light amber color for which our water is noted.

From this reservoir the water is led down to the city by an egg-shaped brick conduit built with a descent of only seven inches to the mile. At the end of this conduit in the north part of the city are



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Plan

Complete Syste

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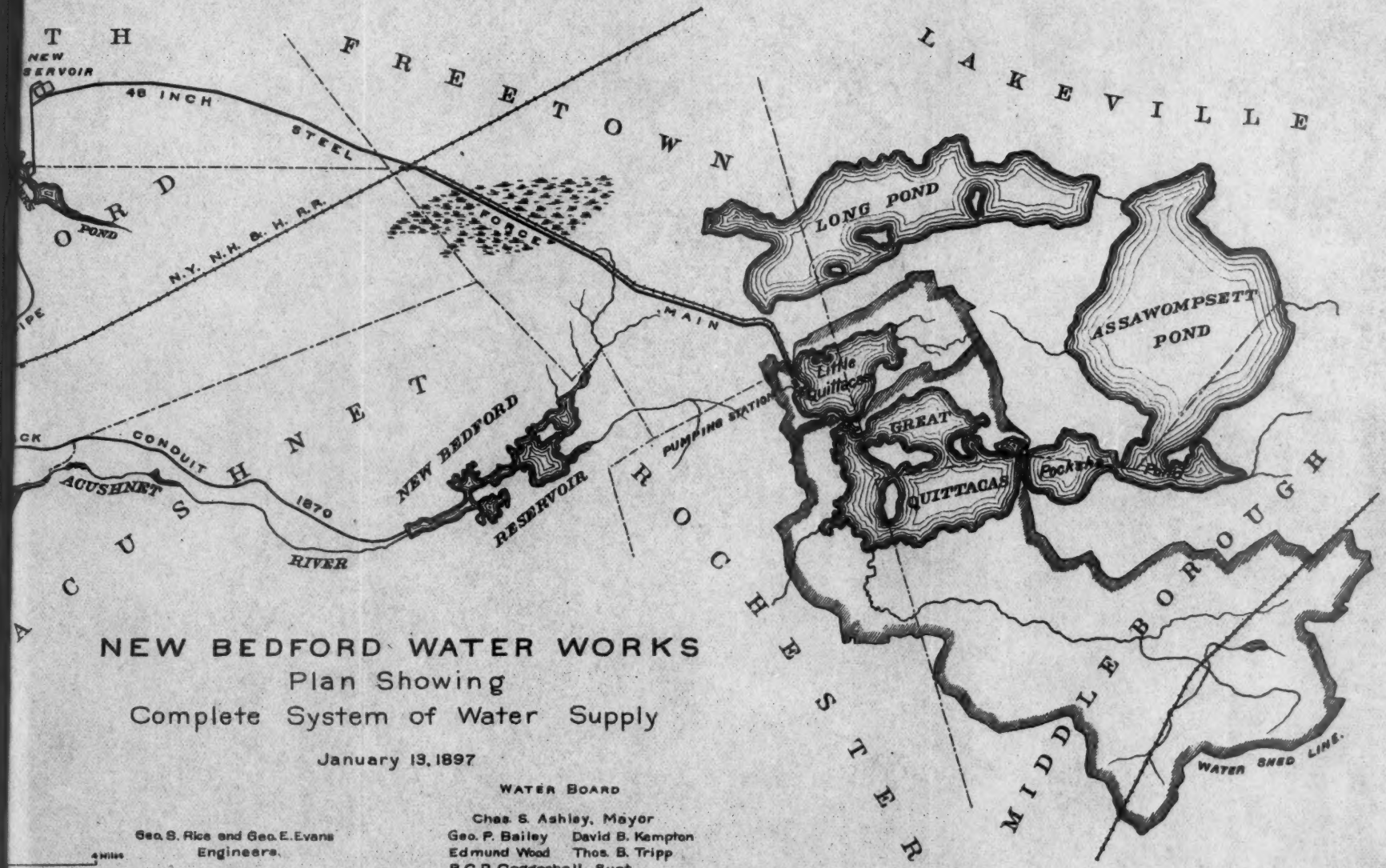
Geo. S. Rice and Geo. E. Evans
Engineers.



NEW BEDFORD WATER WORKS

Plan Showing

Complete System of Water Supply

January 13, 1897

WATER BOARD

Chas. S. Ashley, Mayor
Geo. P. Bailey — David B. Kempton
Edmund Wood — Thos. B. Tripp
R.C.P. Coggeshall, Supt.

Geo. S. Rice and Geo. E. Evans
Engineers.

4 Miles

ASSAWOMPSETT
POND
WATER SHED LINE

located a small receiving reservoir and the pumping station. The water is pumped up to the distributing reservoir on the hill with an elevation of one hundred and fifty-four feet above tide water in New Bedford Harbor.

From this distributing reservoir the water is led in pipes throughout the city.

These distribution pipes were mostly of thin sheet iron, cement lined, but they have been gradually replaced by cast iron until now but one mile of the old pipe remains.

This original system is partly worn out, and in many respects outgrown.

About two fifths of the territorial area of the city, owing to its elevation, can never be supplied by the present works. The growth of the city is now running up into these higher elevations of land which would require the construction of a high service system. We also find that the conduit has given out in a great many ways. It has to be taxed beyond what a gravity conduit of one course of brick ought to be taxed, being allowed to run full, and the roots have forced their way through the brick work, and there are numerous cracks in the arch. The growth of the city has gone out over the line, and streets have been laid out across it, and the arches have not been fortified. For some time it has been a source of great anxiety. The size of the distributing reservoir is not up to modern requirements. Its capacity is only 15,000,000 gallons, while our average daily consumption is about 6,000,000, and our maximum consumption about 7,300,000 gallons.

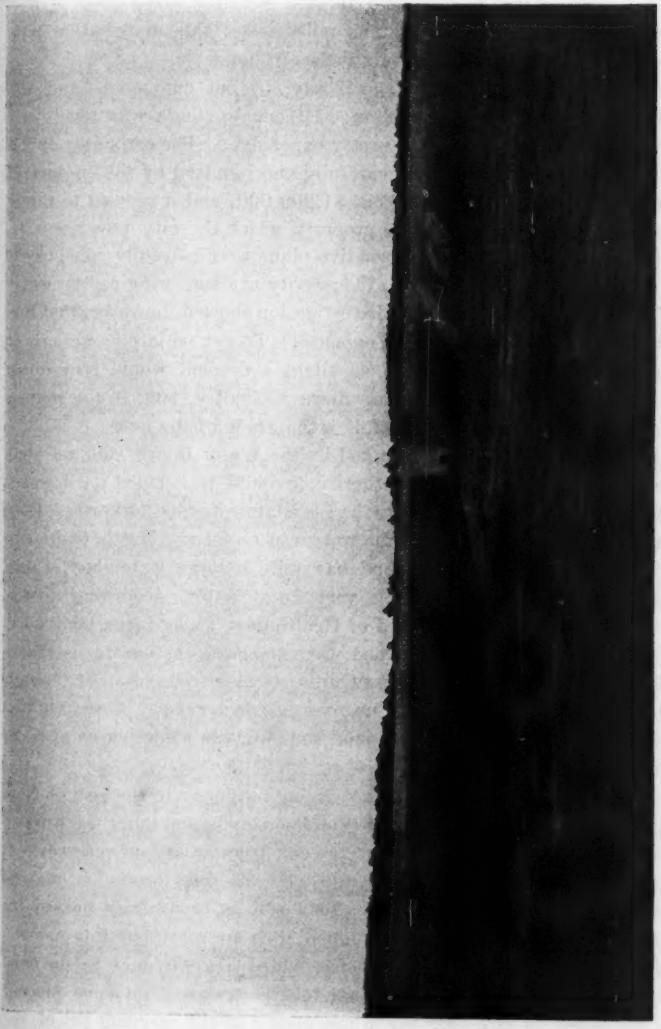
In a dry year, with a low level of water in the storing reservoir it will be impossible to get our daily summer consumption down through the conduit, and as this reservoir only has about one day's supply in reserve, we feel far from safe.

All these defects and shortcomings have gradually forced the management of the Water Department to plan extensive improvements. At different times, we have seriously considered the advisability of taking up some of these defects and remedying them. But it was a better judgment in the end which kept us from yielding to this temptation and made us decide to have the whole system looked into before we did anything. The Water Board of New Bedford secured hydraulic engineers who looked into the whole question of New Bedford's location, its possible supply, its present supply and

all the conditions that surrounded the problem, and who gave us an intelligent and full report before we decided to make any change, or do any patching. We made an arrangement with Messrs. Rice & Evans of Boston, whom you all know, and they came down and went through this work for us, and they submitted, after quite a long examination, occupying several months, a very elaborate report. They discussed this whole question; they gave us alternative plans; they suggested the possibilities of building additions, of patching the present work, but in the end they very strongly recommended a plan which was in effect the partial abandonment of the present system, at least for the present.

The question came before us in New Bedford whether we would have the heroism to begin over, rather than to make patches upon our present system. Probably this problem has come to you all. It is not that New Bedford is wiser than other places, but I think we were fortunate in the fact that we gave out in more than one part. Thus the temptation was not so strong for us to yield and begin to patch our system. One or two changes which have added a few hundred thousand dollars to the investment, make a radical change seem almost impossible. It was owing to this good fortune, that so many parts of our system needed changing at the same time, that we were wise enough to decide to cut loose from it, and begin over.

The plans submitted by Messrs. Rice & Evans to the Water Board of New Bedford provided for the taking of a new supply of water from the Middleborough ponds, to take the waters of Little and Great Quittacus, connect these waters by a deep aqueduct, locate a new pumping station upon the southern shore of Little Quittacus Pond, and force the water up a force-main, eight miles long, to the highest point found in the immediate vicinity of New Bedford. This point is not in the city, but in our neighboring town of Dartmouth. It is about 200 feet above tide water, and, by raising the reservoir, gives us an elevation of 216 feet for our water supply. There were a good many points brought up to show the superiority of this plan. It would forever take care of our high service system; the highest land within New Bedford's limits being less than 150 feet above tide water, it would give us a high enough service for the whole area of the city. This reservoir was to be constructed large enough to hold a large reserve of water, and keep a big supply constantly on tap. We decided to construct it with a capacity of



NEW RESERVOIR, NEW BEDFORD WATER WORKS, SHOWING CONCRETE LINING.

65,000,000 gallons, built in two parts with a dividing wall between. This reservoir was then to be connected with the city's present distributing system, by a pipe four miles long; this distribution pipe to be of cast iron and thirty-six inches in diameter.

This plan was submitted, as I say, by our engineers, and the question came upon its adoption. Of course, there was much discussion upon it. It seemed pretty expensive. The estimates of the cost of this work, made very carefully and itemized by the engineers, involved an expenditure of about $1,200,000, and it seemed to throw away to some extent valuable property which the city now has. In this discussion, different alternative plans were carefully considered. It was hard for us to give up the gravity system, bringing the water down by a gravity conduit. Investigation showed, however, that this would not much decrease the expense. To get so large a volume of water down to the city with so slight a descent would require an enormous brick conduit coming down the valley, built in the wettest part of the whole country, to follow the grade of the land.

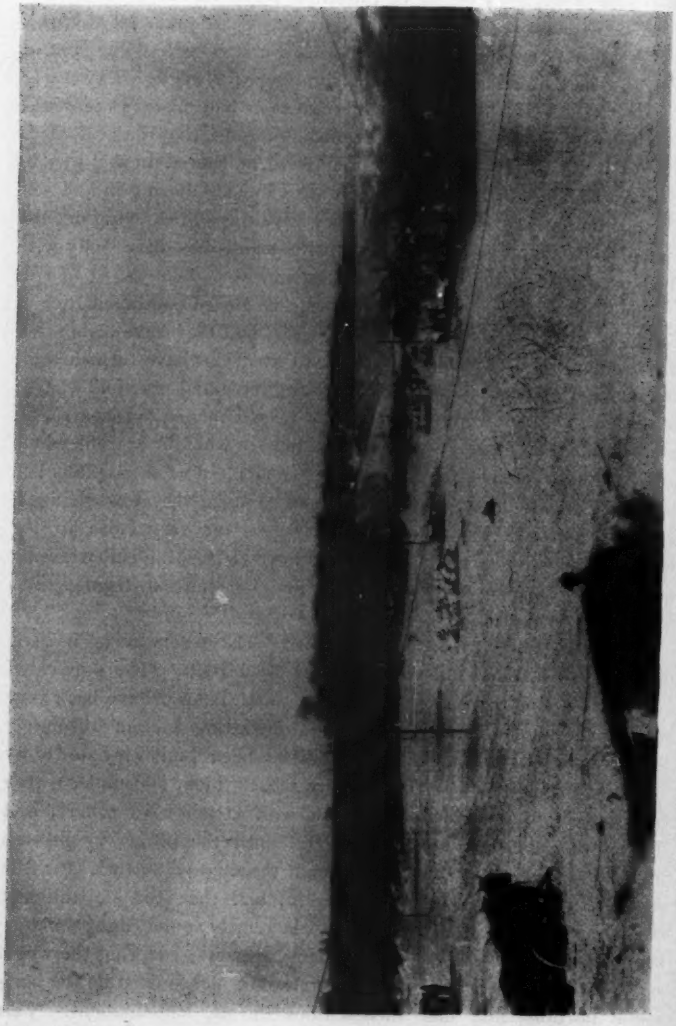
After all, the plan was adopted by the Water Board, and we went to the City Council for authority to build it. The City Council adopted the plan, and went to the Legislature for its authority. They have given to New Bedford the waters of Great and Little Quittacus ponds. Great Quittacus Pond has quite a large watershed, Little Quittacus, a small one. The very finest water, according to the reports which the State Board of Health gave us, is Little Quittacus, the next the Assawompset Pond, then comes Great Quittacus Pond. But it was thought that if Great Quittacus water were brought through Little Quittacus it would give us a very perfect water. Great Quittacus is a very deep pond; we found soundings in some places of sixty feet and a good sandy bottom.

The Legislature passed the act giving authority to the city of New Bedford to take these waters, to condemn lands and build the works; to go into another township for the construction of our reservoir, in the very middle of a town road, to divert the road around it, and to do other extraordinary things. This act, as I say, was passed by the Legislature, and the City Council then appropriated this money. Then they did something which has added a great deal to the convenience of this work, and I am told is unusual in some places. They voted to turn over the whole matter of the carrying out of the act, to transfer all the powers granted to the City Council of New

Bedford by the act, to the Water Board, and they appropriated a lump sum of $1,200,000, to be raised for us as fast as we asked for it, to be expended by us, and the only check put upon all this was that we were to render an account, not of what we were doing, but of what we had done, a wholly *post facto* report, made every three months to the City Council, of the progress we had made in the work. This very much increased the responsibility of the Water Board. They will not be able to say that they were hampered in any way in their decisions of what was best by the Council entering in and deciding differently. We have had every advantage in carrying out the plan of the engineers, of working with a small executive body with frequent meetings and intimate discussion.

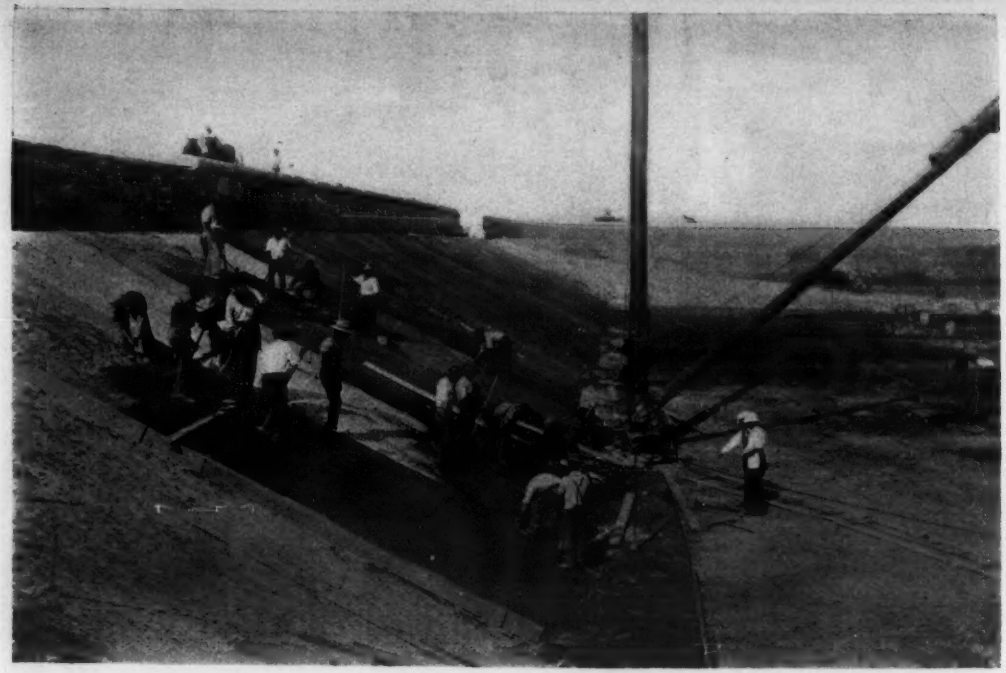
This plan was immediately begun. The Board continued Rice & Evans in their capacity as the engineers, and they have elaborated this system which I have described to you, and have furnished all the engineering service and the plans, and have had practical charge of the work. The original scheme has been changed, of course, in some details, but I am very glad to state here what is a tremendous satisfaction to business men, that the carrying out of these plans has been very satisfactory; that we have had to make very few changes, and the contracts have been completed so far very close to the original plans and specifications. We have not had the embarrassing questions of extra work and changes, and the endless disputes into which they lead.

This plan can be further described. The reservoir is a little different from some others which have been built. The excavated earth was found to be exceptionally good, but we have been very careful, very conservative, may be, in providing for an absolutely tight reservoir. The embankments have been built very slowly by very gradual layers of earth, only five inches thick, and under a very rigid inspection, sprinkled, and rolled with steam road rollers, and then another five-inch layer, and so on until the proper height was reached, then excavated, after it had thoroughly settled, for the retaining wall, which has been built in, and then the embankment carried up above. This has made an extremely sound, tight embankment. But we have gone to a further expense,— covering the whole surface of the reservoir with concrete, six inches deep on the horizontal portions and nine inches thick on the embankment. This reservoir is now completed, with the exception of the gate houses,



NEW RESERVOIR, NEW BEDFORD WATER WORKS, SHOWING CONSTRUCTION OF CONCRETE LINING.

NEW RESERVOIR, NEW BEDFORD WATER WORKS, SHOWING CONSTRUCTION OF CONCRETE LINING.



NEW RESERVOIR, NEW BEDFORD WATER WORKS, SHOWING CONCRETE LINING ON SLOPE OF EMBANKMENT.

48-INCH STEEL FORCE MAIN, NEW BEDFORD WATER WORKS. CUTTING OFF PILES FOR FOUNDATION THROUGH SWAMP.

48-INCH STEEL FORCE MAIN, NEW BEDFORD WATER WORKS. PIPE READY FOR TESTING.

48-INCH STEEL FORCE MAIN, NEW BEDFORD WATER WORKS. CUTTING OFF PILES FOR FOUNDATION THROUGH SWAMP.

and we shall be very glad to show it to any of you who would be interested in a further examination of this portion of the work. We have taken the water into the reservoir on the middle of the east side and taken it out on the middle of the west side, looking out for anchor ice, which has sometimes bothered us in New Bedford. We have a by-pass which runs round the reservoir through which we can pump. We have it arranged so we can take water out of either half. We have built a very strong dividing wall, which we think is heavy enough to allow one part of the reservoir to be used at a time. This will facilitate the important cleaning of the bottom occasionally. The dividing wall is built of such a height, that, when the reservoir is full, the water will flow over the top of it and appear as one large sheet of water.

The next point in the construction, which will be of interest to you, is the force main. The engineers recommended that this be built of steel pipe. Some of our members are pretty conservative, and we believed in cast-iron pipe. This matter was pretty thoroughly discussed. It is a 48-inch pipe, and we obtained careful estimates of the cost of this pipe, both in cast iron and in riveted steel. We tried to get authoritative opinions in regard to the life of steel pipe. They varied very much in proportion as to whether you asked a friend or an enemy of cast-iron pipe to express an opinion. [*Laughter.*] But in the end we thought it the extreme of safety to figure twenty years as the minimum life of a steel pipe, when careful attention is paid to the coating. On that basis we can compare the cost of a 48-inch steel pipe with the cost of an iron pipe of the same diameter. The difference in cost, if put at interest, will amount to enough in twenty years to pay for an entirely new steel pipe. This strong argument added to others brought up by our engineers, influenced us in deciding upon steel pipe. But we concluded to have it of good thickness — $\frac{5}{16}$-inch plates.

Another question which was very interesting to us was the rather original scheme offered to us by our engineers, that this pipe should be built differently from any other pipe of which we had ever heard. That is, that it should not be constructed with telescopic joints, as most such pipes are, but with butt joints, with strap on the outside, and with countersunk rivets, giving an uninterrupted inside surface for the flow of the water. This was considered by the Board; the alternative plan being the use of the regular telescopic joint. This,

as I say, was a very interesting proposition to us, and we went into it quite elaborately, and were quite undecided which to take. We were interested in this idea of a smooth pipe. We had the opinion of many boiler makers, who thought that a pipe could be built as strongly with that method of construction, with butt joints, as with telescopic joints. We judged and we received corroborative opinions that the butt joint pipe would cost considerably more than the telescopic joint. We received bids on both methods of construction, and the cost for the whole eight miles and more of 48-inch pipe, built with smooth butt joints, exceeded the cost of the telescopic joints a little over $20,000. The Board decided in the end not to use the butt joint, but to use the telescopic joint. We do believe that that other plan has a great deal of merit. It would certainly allow a larger body of water to flow through, and consequently the pipe could be reduced in size.

Then the question of coating came, as it comes to you all who are building this kind of work, and we considered different processes. Some of them which we looked into were very interesting and seemed to provide for a great lengthening of the life of the pipe, but in some work which we saw, we could not help giving most of our attention to the places where the coating would inevitably get knocked off. When the pipes are shipped by rail from the place of manufacture and unloaded and teamed in such heavy sections, thirty feet long, it is impossible to keep them from being knocked, enough to break any ordinary or extraordinary coating on the outside. Of course the strength and the durability of the pipe would not be much longer than the weakest place in it, and there are so many places in the expensively coated pipe which would have to be patched in the trench with ordinary material, that we decided to have our pipe thickly coated with the regular asphaltum mixture, and then give extraordinary attention to the patching of the coating during the process of laying. This has been done. The pipes have come coated in asphaltum, and they have been very carefully and often painted with P. B. paint until after the final testing and covering of the pipe. This pipe is also subject to a heavy hydraulic pressure test before it is covered with earth.

The next point of interest is our railroad. The line of the force main is crossed, about half way, by the main line of the New York, New Haven & Hartford Railroad. There is one important problem

which interests every one connected with water works, to get the coal at the very lowest price at the pumping station, and the question came up as to the advisability of building a railroad. We figured up the cost and the interest upon it, and the saving in the price of coal over any other method of getting coal out there, and it seemed as if we could hardly save the interest on the cost of the railroad. But another point came into the calculation which affected our decision. This force main goes through a very bad section of country. It crosses the very large and hitherto almost impassible Bolton Cedar Swamp. You can here drive a pile fifteen feet at almost one stroke of the hammer. It was a pretty bad place to get through and put a pipe line. It was found by estimates made, that quite a portion of the cost of building a railroad could be charged off to construction account. That is, that a line of pipe built through such a territory could be constructed for a very much smaller cost with a railroad paralleling it. Then, of course, we figured upon the fact that the material for the pumping station, the engines and the superstructures, would also be carried by this railroad, if built. At length it was decided advisable to build a regular standard guage railroad from Braley's Station on the New York, New Haven & Hartford Railroad to the pumping station at Little Quittacas Pond. This railroad was one of the first things built, and is now being used to help the construction of the force main, which runs along beside it. There were no land damages on this railroad, as a strip five rods wide through that whole country was taken for the pipe line. The idea, too, is to carry this railroad right into the pumping station. At the end it passes on an elevated trestle into the coal shed. The coal, after being delivered on top of the trestle by the railroad, passes down hill all the way to the grate bars. This coal shed is to be built large enough to take in a full cargo of coal, so that a cargo landed in New Bedford can be run up and be placed in this shed without much trimming or handling. In this way we have the coal at the point of consumption at a very moderate price.

The contracts have been let for the placing of the engine foundations, and we are now about to put out the contracts for building the superstructures on the shores of the pond.

The usual vexed question came to us, too, about an engine and pumps. We seemed to incline towards a specially designed engine. Perhaps we were influenced in this decision somewhat by the fact

that New Bedford, a few years ago, built a bridge, and it was in the form of bidding that every contractor should submit with his bid the plan he proposed to build. There was an attempt made to compare them, and the contract was awarded and the bridge was built, but it would take a very courageous County Commissioner in New Bedford to ever build another bridge after that system of bidding. We decided to have an engine drawn, and then to have the bids all made upon one basis for comparison. We therefore made an arrangement with Mr. Leavitt to design two 10,000,000-gallon engines. He has prepared plans and they have been put out for bids, and the engines are now being constructed. In the contract for them, we have put in a forfeit for each day's delay in delivering them, and a proportionately liberal premium for completing the engines and pumps in less than the specified time. The first engine is to be ready for regular work in twelve months from the date of the signing of the contract. And the second engine in sixteen months.

One other point which will be as interesting to you as any in the work of our further water supply is the position we have taken in regard to maintaining the purity of the water. This came up very early in our discussions how we should do this, and a strong opinion developed among us that we should take every possible precaution, even to the absolute ownership of the shores. But there were a great many difficulties in the way of doing this, the main one being the cost. Our new supply is in a picturesque country, and cottages had begun to spring up around some of these ponds, and the value of the land would soon be on the increase. We thought with the present values of land there, that we could well afford to buy it, provided we did not have to pay an inflated price for it. We had heard often enough of the way in which some cities have had to pay for land, — of the way in which all cities have to pay for land when it becomes known that a municipality is the purchaser, and we tried to conceive of some plan by which we could acquire this territory for the regular going market rate. This was quite a problem to solve, and we tried it in various ways. One difficulty was the fact that we had no money for this purpose. All our money was appropriated to carry out the plan which was submitted to the City Council with the itemized estimate, and that only allowed of an expenditure for lands necessary for construction along the line and for the pumping station, etc. It was at last suggested that as we were so confident that this

would meet with the favor of the citizens and they would back us up in it, we might do it on our own personal responsibility, and we considered seriously the plan of going to the banks and negotiating a private note to raise $50,000 or $60,000 and to begin the work. Some of the members of the New Bedford Water Board are treated with great respect at the banks. [*Laughter.*]

This plan seemed to have much to commend it, and we came very near following it, but at last we came to the conclusion that it was a pretty risky thing to do. [*Laughter.*] In the present state of public opinion in regard to municipal officers, it would be almost impossible to do a thing like that and to pursuade the ordinary critical citizen that this land conveyed to private individuals for the purposes of New Bedford, and afterwards reconveyed to New Bedford, that some portion of it, some residuum of value did not adhere to the fingers of the men who handled it. [*Laughter.*] This was quite a convincing thought, and we gave it up. We accomplished the same purpose in another way, and as a great many of you are probably municipal officers, I will describe the way we did it. If we went to the City Council and asked for the money for this purpose, the intention of the city would be immediately advertised to every owner of land in the neighborhood. But if we could keep the expenditure quiet for three months, acting through unsuspected agents, we could secure possession of a large part of the land at fair prices. The Mayor of the city is *ex-officio* a member of the Water Board, the Treasurer is *ex-officio* the Water Registrar, and when we all became convinced that was the proper thing to do, we went ahead and did it. We bought the land secretly through agents and we quietly passed the bills and the Mayor approved the special audit and the City Treasurer paid it. [*Laughter.*] It was a source of gratification to us that such high-handed procedure was so unanimously approved, that the action of the Water Board in going ahead and buying the land in such a way was commended. It is rather an unusual course and I do not know that it can be recommended. [*Laughter.*]

We began with small ideas. We did not know what other cities had done in this regard. When we were pretty well along it strengthened us in our judgment to hear that in the city of Nashua, Mr. Holden, at the head of a private water works corporation, bought up their water shed. If it were prudent and advisable for a dividend-paying private corporation, it was a good move for a city to acquire

the title to the land actually bordering upon the source of supply. I go into this phase of our work quite fully because of the interest it has aroused in the expert on my right, Professor Sedgwick, and I am very glad to see that New Bedford's action is approved by such an acknowledged authority as he. The city had been using the waters of little Quittacus Pond for some time, and had taken no steps to acquire the land bordering on that lake, so the people down there never thought that it was a part of a water scheme to take the land.

One piece of good fortune aided us very materially. There was a gentleman who had lived on the shores of Great Quittacus Pond, who had conceived the idea of controlling this pond himself. He had begun to acquire the lands, and had become the owner of quite a portion of this shore by actual purchase. He had pursued this object as his hobby, in one sense, and with great earnestness until he had secured options on quite a number of other lots along the shore. Mr. Turner's views were most commendable. He strove for the fullest protection of the shores from an æsthetic point of view. He had a very modest cottage on the north end of the pond, and all his options had in them the provision that no wood should be cut, and no little buildings should be put up within sight of the shore. You can conceive that this sort of an idea was in exact sympathy with the object of the New Bedford Water Board, which was to get possession of all the land before the trees were cut off, and to preserve it as it was. This gentleman had made good progress in acquiring the shores of this pond when he unfortunately died.

We then paid a call on his attorney and agent, Mr. Henry A. Wyman, a Boston gentleman whom some of you know. We made a very fair deal with him for the estate's lands. The City of New Bedford told him very frankly what they wanted of this land, and were met as frankly. But the estate only owned a comparatively small portion of this shore right, but they possessed valuable options on others, which might have lapsed, the estate not caring to go on with this idea. We made an arrangement by which this gentleman acted as our agent in going around and closing up these options for us at the old original prices which had been arranged, before any city loomed up in sight as a basis of value. These lands were, therefore, purchased by him before there was anything made public. Then other lands were bought in a similar way, and when the fact was disclosed that it was the city which was buying all this land, we

had acquired three fourths of all the shore on both ponds. We then thought that this action had gone far toward fixing what was the normal standard value of such land in that locality, and that there was not much danger then in letting it out and dealing with the balance of the owners in an open way. But it was a grimly humorous fact when it became noised abroad that the powerful and infinitely rich city of New Bedford was really the party who had been anonymously and mysteriously buying lands about the pond, how immediately the value of all the remaining land went up. Some of the farms, whose owners had really offered them for sale only a year or so before, in order that they might go out West unincumbered, and build up a new farm out there more fertile than this, immediately jumped in value. The owner felt that he was bound closer than ever to this land of his ancestors, and that nothing could sever the strong heart bonds he felt for these lands except a good, liberal payment of money in the first instance, and secondly, a liberal payment for our wanton destruction of his sentiment and love of home. [*Laughter.*] But we found soon that this proposition, like a great many other propositions, was subject to a liberal trade discount. [*Laughter.*] This may sound a little heartless stated in such a bald way, but not to a body of gentlemen as familiar as you are with a city's usual experience in buying land. Of course, we have always calculated to pay the full market value for all land, and most of the prices paid have been extremely liberal, but not inflated.

The remaining land is now being acquired, and we find that it is to a great extent true; that the values now fixed by these previous purchases does govern, to a certain extent, the value of the remaining land. We have bought around these ponds, already, about one thousand two hundred acres, and we have paid for this land about fifty-three thousand dollars, and this includes some ten buildings, houses, and barns, and some quite ambitious ones, which we also had to buy.

The land varies in depth from the pond. One piece is only about 320 feet deep, and some is 2,800 feet deep from the ponds. There were cases, of course, where we could buy the whole farm just as cheaply as we could buy a few feet of front. Where a person overvalued the frontage of his farm on the pond, and would not sell it for less than he would sell the whole farm and emigrate, in some cases we did buy the whole farm. We had the remarkable experi-

ence in two cases of having a man charge an exorbitant price for the portion on the pond, of then buying from him the whole farm for only a little more money, and after a month of having the man come back to say that he had changed his mind, and wanted to return and live there. And he bought back from us the part that we did not want [*Laughter*], and at a very fair price.

This, gentlemen, is a pretty rapid and not very brief review of the work which has gone on in New Bedford toward getting this further water supply. We hope that it will stand the test of actual experience. I think we all dread the I-told-you-so kind of critic, who, after the lapse of ten years, may be, and standing in the full glare of what is then actual knowledge, will think it funny that we could not have foreseen such self-evident results as he sees then. We have had to settle a great many engineering questions, and I have stated the decisions we arrived at. But we are not so full of conceit as to believe that we have settled these questions for you or for the world. Some of these disputed questions will probably continue to be mooted in spite of what has been done in this remote corner of the State. We have builded as well as we knew, we have been assisted and to a large extent guided by our broad, sagacious, and admittedly level-headed engineers, and we have striven to turn over to the confiding City Council of New Bedford and to our liberal citizens, a work which shall stand the real test which we all care about, the test of actual use, and which, when completed, although constructed by a municipality, shall represent as nearly as possible the full cash purchasing value of the money which it has cost. [*Applause.*]

DISCUSSION.

Mr. Fuller. I would like to ask Mr. Wood what was considered the life of cast iron. He has told us that they finally concluded if the steel pipe would last twenty years, it would be better to use that.

Mr. Wood. Mr. President, I can only answer that like the man who at the age of sixty years set out a locust post to find out how long it would last in the ground. [*Laughter.*] We did not find anybody who was able to say from actual experience how long a cast-iron pipe of that diameter and necessary thickness would stand in such a place as that. It would be a great many years.

When you stop to think of the way we ultimately settled that question, it does not matter, for if the difference between the cost of iron and steel would allow us to build of steel and throw it aside and build another of steel every twenty years, we could go on having steel and probably have a new one just at the time the cast-iron pipe would have worn out. [*Laughter.*]

The PRESIDENT. Mr. Evans, the engineer of this work is present. I should like to hear from him in connection with the work.

Mr. EVANS. One thing that caused us to settle on steel pipe was its lightness. Cast-iron pipe in 12½-feet lengths weighs from four and a half to five tons, and in the country where this pipe is laid we are not close to any highways, and those which are convenient are very poor. The whole line is across country, as you might say. With the exception of crossing the highways, the line is nearly a a quarter of a mile from them, and to get cast-iron pipe on to the location, a road would have to be constructed for that purpose.

There was one thing that you might get a wrong impression of from what Mr. Wood said in regard to how the pipe is made. It is not made exactly in accordance with the boiler principles. A boiler is usually made with a small section and a larger section. These sections are all one size but taper and are inserted regularly, so that the force of the water never comes against the bevel edge of the plate inside. The larger ends of the rings of the pipe are towards the pumping station, and the smaller rings, which are ⅝ inch less in diameter, are towards the reservoir. The smaller end is 4 feet and the larger 4 feet and ⅝ of an inch, inside diameters.

The difference in cost, if I remember correctly, between the cast iron and the steel for the same length was about $138,000 in favor of steel, and taking that into consideration, and the lighter weight, we thought better to recommend the steel.

The coating that Mr. Wood spoke of, we have very little difficulty with on the inside of the pipe. The pipe was delivered coated very nicely inside, but the outside of the pipe is more or less liable to injury. The greatest injury comes from car stakes. The pipes are loaded in two tiers of four thirty-foot sections, per car, and in going down the steep grades from Pittsburg east the pipes will slip more or less, say six inches, and in a great many cases they nail blocks between the top end of the car stake and the pipe, and they scrape off the coating for a space of three inches wide and six or

eight inches in length. As soon as we receive them, if they show any signs of rust it is thoroughly scraped off and covered with P. B. paint. At the field joints the coating is burned off while they are driving the joints. That has to be gone over with paint on both sides before the water test is made. After the sections are laid and thoroughly calked, they are tested by a 250-pound water pressure, and any leaks that show are calked and the places painted over afterwards. Up to this time we have not had any stream of water from them large enough to show in a photograph.

Mr. STEARNS. I would like to ask Mr. Wood whether the bids for cast-iron pipe and steel pipe were on the same diameter, or the same carrying capacity?

Mr. WOOD. Mr. Evans can answer that better than I. We did not receive bids for cast-iron pipe, but in looking for information to guide the Board, we received estimates on both kinds of pipe for comparison. Mr. Evans can answer better as to the basis of comparison.

Mr. EVANS. I think the Board asked us to compare the same diameter of cast iron with steel, and my impression is that it was done on the same diameter of pipe. This pipe line differs from the East Jersey in the way the plates are put together. Each 30-foot section is made up of five sections of steel plate a little over six feet each; each of which fits inside of the next, going in the way in which the water flows. In the East Jersey line there was a small section, and then a greater section, and the current of water comes against the bevel edge of each plate on the smaller sections.

Mr. GARRETT. Mr. President, I am not quite clear that I understood Mr. Wood in regard to the interest on the difference of cost. Do I understand him to say that the difference in cost, which Mr. Evans said was $138,000, put at interest for twenty years would pay for a new steel pipe line?

Mr. WOOD. I was of the impression the difference was a little more than $138,000 between the cost of one and the cost of the other. The difference between the cost of the steel and the cost of the iron pipe, if put at interest and compounded, as it naturally would be, would provide, at the expiration of twenty years, a sufficient sum to put in a new steel pipe. Of course, the life of this pipe would be greatly determined by the care which was taken in its manufacture, and that point I did not touch upon in my review of

this question of the relative values of iron and steel pipe. If we were extremely careful in our inspection of the steel pipe, of course it would last a great deal longer than it would otherwise. So, I might mention that as an additional precaution taken to insure the correctness of this decision of the comparative values, the manufacture of the steel pipe has been rigidly inspected at every stage. The Pittsburg Testing Laboratory have analyzed the metal continuously, as it is rolled at Homestead. Every plate is then carefully inspected. We have inspectors of the riveting and caulking in the shops, and then, finally, in New Bedford a corps of inspectors watch the laying, the riveting, and the testing in the trench.

And we have been led to believe, from those who have experience on other similar work, that the life of this particular steel pipe line will be much more than twenty years.

Mr. GARRETT. It was a matter of interest to me whether there was really enough saving on the difference between the price of steel and the price of cast iron to build a new conduit, say roughly estimated at $250,000. If that is the difference between cast-iron pipe and steel, I think the cast-iron pipe makers better go to making steel. [*Laughter.*]

Mr. COOK. I would like to state that I examined last fall a 20-inch main, uncoated, which had been down 30 years at Salem, and with the exception of a little corrosion on the inside, it was practically as good as ever. We had the Smith Tapping Machine Company come to inspect it, and they guaranteed that they would make the tap in twenty minutes, but it took them an hour and a quarter to make it. There was a thick layer of rust on the inside.

Mr. COFFIN. Mr. Wood stated, I think, that in comparing the two kinds of pipe, the butt-strap pipe and the telescopic joint, it was considered the telescopic would have to be made of a larger diameter to make allowance for the friction, owing to the joints and the rivets, and Mr. Stearns asked Mr. Evans, whether a similar size of cast-iron pipe was figured on for the same reason. Now, I would like to get an expression of opinion as to whether in the course of a number of years, and as time goes, the pipe gets dirty and the discharge decreases,— and perhaps the most critical point of a pipe in its capacity is after the discharge has decreased,— it would make any special difference in the steel pipe, whether the rivets were countersunk and the joints butted or not. It has occurred to me that after

15 or 20 years the tuberculation would bring them all down to about the same carrying capacity.

The PRESIDENT. I would like to have Mr. Brackett give us some ideas on that subject.

Mr. BRACKETT. Mr. Coffin has raised a question to which I have not given much thought, but it is one well worthy of attention.

In regard to the general question of the use of steel or cast iron, I think that the conditions in each case must be considered in deciding which it is advisable to use. The advisability of using steel or cast iron was very carefully considered for the Metropolitan water supply, upon which I am now engaged, and for our work it was not thought advisable to use steel pipes. The conditions, however, were very much different from those existing at New Bedford. Our pipes were to be laid in public streets where the chances of injury to the protective coatings were very much greater than they would be if laid in property belonging to and under the control of the Water Department. Furthermore, we do not desire in the course of twenty, or even thirty or forty years, to relay the pipes. It is very difficult even now to find a place in the streets to put one pipe, and it would not be practicable to take up the one we had in use to lay another, and it would not be possible to find a place to put the second one. These two reasons alone would have led us to use cast-iron instead of steel. On the other hand, where a city owns a right of way, where in twenty years they can replace the pipe, it may be advisable to use steel.

Mr. COOK. There is one thing that has been a conundrum to me. In Salem we have 6 and 12 inch pipes on bridges for distances of one or two hundred feet with no packing at all, and they never freeze. Now, I do not understand why it is necessary to lay 48-inch pipe so deep as they do here in Boston.

Mr. BRACKETT. The 48-inch pipes are placed, where possible, three feet below the surface.

Mr. COOK. Aren't the trenches about nine feet deep?

Mr. BRACKETT. The trenches are ordinarily from seven and one half to eight feet in depth, but for many reasons this depth is varied, in many cases. The depth of three feet to the top of the pipe allows the 48-inch pipes to pass under the gas service pipes, and is as near the surface as we can bring them, and keep under the gas service pipes. In some cases the 48-inch pipes are laid up within eighteen

inches of the surface of the street. That we are obliged to do to get over sewers. Then, in other cases, even for considerable distances, it is a question of either carrying the pipes down deep enough so that the top of a 48-inch pipe is below all house sewer connections, or of building a second sewer in the streets to take care of the sewage from one side of the street; and I am now considering the advisability of laying a considerable length of 48-inch pipes with the tops from eight to nine feet below the street surface for that reason. These are the conditions that govern the depth to which our pipes are laid. I do not think that it follows because pipes can be laid exposed for one or two hundred feet on a bridge without freezing, that a pipe line ten miles in length on the surface of the ground would not freeze.

Mr. GILBERT. I would like to say a word in regard to the shape of the pipe, whether it is to be perfectly smooth on the inside or not. Now, I do not know why it should not work in large pipes, the same as in small pipes. A pipe that has fittings at all the joints and elbows will corrode much quicker than where the pipe is smooth without any fittings; and I think that pipes will corrode faster where there are obstructions of that kind than where they have a free, smooth run right through. In the case of shut-offs on service pipes many of our water-works men use shut-offs that do not have a free, round, smooth hole through them. Many of these cheap shut-offs are made with a sort of oblong hole and are not smooth when they are finished. My experience has been that the smoother the pipes are, and the less obstruction there is, the less the pipes corrode.

Mr. EVANS. In regard to the question the gentleman has just brought up respecting the house service taps, there is a corrosion which always collects, and I always supposed that that was caused by galvanic action between the two metals more than by the obstruction in the pipe.

Mr. GILBERT. I would like to ask the gentleman if he has not noticed the same thing where the pipe was jointed and also had elbows?

Mr. EVANS. I know elbows fill up frequently, but these were cast iron, and perhaps uncoated.

The PRESIDENT. I would like to ask any gentleman here who has watched the action of water on pipes, whether, where there is no flow at the faucet, that is, no current, the corrosion is greater than where there is a flow?

Mr. Cook. In my experience no service has corroded so much as where the water has been turned on. There seems to be a galvanic action where the water is turned on. If the cock projects beyond the diameter of the pipe, I think there is not so much corrosion as when flush with the inside of the pipe.

Mr. Brackett. I think there is one reason that has not been mentioned why a pipe not in use will not fill with rust as quickly as one through which water is being drawn. A pipe in use is subject to a constant change of water and to a fresh supply of oxygen carried by the water, while the pipe that is not in use contains water from which the oxygen has been taken up by the rusting of the iron. As soon as the oxygen in the water is gone there will be no further rusting until a fresh supply of oxygen is available, and it is the practice in the use of sprinkling systems to avoid changing the water in the systems, so as to prevent the rusting; and it is also a fact that in green-house heating systems, where the same water is used over and over again, the pipes do not rust to any great extent. I think you will find that the branch pipes leading to hydrants are tuberculated less than the supply pipes where there is a constant flow of water.

In regard to the rusting of wrought-iron service pipes at connections; where coated pipes are used this would be accounted for by the fact that the coating is more likely to be broken at these points, and that where cut pipes are used an exposed end of iron is not covered by coating, and at the connections there will be a collection of rust. Of course, any obstruction would tend to collect any sediment that was passing through the pipe, and the collection of rust is more likely to be found at the junctions than on the smooth portions of the pipe.

PUMPING ENGINES.

BY ARTHUR J. L. LORETZ, M. E.

[*Read Dec.* 9, 1896.]

The subject of pumping engines, on which I shall speak to you to-day, dates back two centuries, and the limited time to-day only allows a rapid glance at the subject. A slight reference will be made to some of the principal machines for the purpose of showing you how little progress in the fundamental principles has been made during two hundred years in the economical handling of water.

If the noted constructors of those days had had the facilities of the present date, as regards tools and materials, at their disposal, I feel confident that there would be little left for the constructor of to-day to show as his progress beyond his predecessors.

After studying the examples of Bélidor, Héron De Villefosse, and others, as published in their works on hydraulics, written over two centuries ago, and later following the work of the illustrious Watt, in his almost exhaustive treatment of steam and its appliances, one cannot help but feel somewhat humbled that so little progress has since been made in machinery so universally in use and of such vital importance.

The hydraulic engines of Bélidor are certainly as perfect in their principles of pump mechanism as those of the most recent build, and one even gets suggestions from the descriptions and illustrations in his work entitled "Architecture Hydraulique" well worth the study of our present engineers.

The "Machines a colonne d'eau," described and illustrated in Héron De Villefosse's works, leave little for us to improve on as regards the direct acting pumping engine and the double acting piston pump mechanism which we still find our pump builders of to-day using. True, these were pumping engines operated by water pressure, but I found all the principles embodied in these machines that are used in the single direct acting and duplex steam pumps of to-day.

Some twenty-five years ago, I was much amused by the effort of a monopoly of direct acting steam pump makers to enjoin others from

constructing direct acting steam pumps, which had been put upon the market. I then gave the matter a thorough study, and after carefully studying some of our old masters saw how perfectly preposterous and worthless the claims were of these monopolists.

When one considers the grand and glorious workings of the monster compound pumping engines found in Holland, which were built nearly three quarters of a century ago, it is with a feeling akin to shame to the profession that I stand here without being able to point out to you examples emanating from up-to-date equipped establishments, which compare favorably with those masterful works. The little progress which has been made in this art speaks volumes for the skill of our early engineers, and it is very humiliating to us of to-day. It seems as though we were most closely limited in our surroundings, and that we revolve in the same circle and tediously repeat ourselves after a short period. Is it possible that the great old masters have reached the point of perfection, or have we less knowledge and boldness than our predecessors?

A partial answer to the above query may be found in the fact that the manufacturers of pumping engines have been, and are, unfortunately for the progress of the art, corporate monopolies, whose influence has been, and is, used to suppress innovations which might cause changes in the types of work in which they deal.

During these thirty years of untiring activity in this profession, I have often found myself alone in advocating the superiority of the fly-wheel pumping engine, knowing that this type was the one destined to meet the wants of the people, as simple, durable, and reliable machines.

From these principles I have never swerved, and can point to-day with consistency to examples of twenty-five years' constant and efficient work of the crank and fly-wheel vertical pumping engine, although I do not know where to find an example of a modern type of direct acting pumping engine that compares favorably in durability and efficiency to the old Holland engines.

With the knowledge of the state of the art in the past, let us now consider the necessary steps to be taken to construct a pumping engine that shall mark an advance step, bearing in mind continually that simplicity and durability of mechanisms, combined with efficiency, least first cost, and maintenance, are the all important factors in this problem. No matter how perfect and efficient a machine may

be, if its first cost and maintenance reach that point where its efficiency does not offer an inducement to the capitalist to make a profitable investment, the machine is a failure, and becomes but a mechanical toy, or useful only as an experimental apparatus.

The perfect steam pumping engine may be considered as an apparatus composed of two separate elements; one, the motive part, which consists of the motor or power generator (boiler and engine), and the other, the pump itself. The first should consist of a perfect steam engine plant, constructed so as to convert the heat produced by the coal into power, with the least possible waste.

Since, as a general rule, the load of resistance to motive power in pumping engines is almost constant, the problem of consumption of steam with its expansive powers, with regard to its most economical utilization for motive power, is easily solved.

Now, what may be considered the best and most available steam motor, the form that offers the least frictional resistance, is the vertical rotative type of engine, arranged with compound tandem or cross-compound cylinders, or in other words, a perfect high pressure and a perfect low pressure engine combined; also proportioned to work against the resisting force so as to expand the steam from twenty to twenty-five times its original volume at 80 to 90 pounds boiler pressure, and working at a piston speed of from 400 to 600 feet per minute. By quick piston speed we reduce the condensation of steam to a minimum in shortening the period of time which exists from the moment the steam leaves the generator until it performs its work in the cylinders.

It will be well to note right here that the high and low pressure cylinders are to be treated as two separate and distinct engines; the steam from the boiler or generator to be used for effective work on the piston of the high pressure cylinders only, live steam for re-heating purposes to be ignored entirely, either for jacketing or re-heating purposes.

Instead of steam jacketing, a thorough insulation of the entire cylinders and chests is to be made by a heavy and well constructed covering of asbestos to prevent radiation of heat, and which is sufficient to guard against condensation of steam, and also maintain the regular working average temperature in the steam cylinders. The use of live steam from the boiler for re-heating the steam, in coils, while on its passage from the high to the low pressure cylinder,

should also be dispensed with as wasteful in the extreme. Steam at ninety pounds pressure would only have an imparting temperature of 330 degrees, and its quantity is limited to the radiating surface of the coils, while its heat is taken direct from the coal consumed on the grate.

I would suggest that the boiler be invariably located in close proximity to the steam cylinders of the engine, and the exhaust steam from the high pressure cylinder carried through re-heating tubes constructed in the back connection of the boiler where the waste gases pass off to stack, at a temperature of from four hundred to five hundred degeees. From these tubes, or re-heater, the low pressure cylinder is supplied with its steam as from a secondary boiler, whose steaming surfaces are exposed to an average temperature of 475 degrees, with a heating capacity equal to the entire flue area of the boiler, while with the live steam coil the imparting temperature is but 330 degrees with a radiating capacity equal only to the radiating surface of the coil. By this means a higher temperature is obtained from the re-heater, and water in entrainment is re-evaporated. In a similar way the feed water for the boilers should be treated while being pumped from the hot well to the boiler through a similar heating contrivance without robbing the boiler of any heat.

I have found this plan to work admirably, and the initial steam pressure of the low pressure cylinder has been raised exactly to that of the terminal of the high pressure cylinder, an end I had been unable to accomplish by moderate sized steam coils.

The re-heating device should be located in a flue chamber between boiler and stack, provided with by-pass dampers arranged to carry the escaping gases direct to chimney, when the engine is stopped and no circulation of steam exists in the re-heating tubes, in order to prevent them from burning out, and to admit of their examination while the boiler is in action. The feed water heater should be placed in the same chamber as the re-heater, but located in such a manner as to receive the heat of the escaping gases only after they have passed the tubes of re-heater, in order that the latter may receive the highest temperature. In all cases I would suggest the use of brass tubes for re-heaters and feed water heaters.

With a first-class steam generator, a compound engine capable of expanding steam to twenty-five times the volume of steam admitted in the high pressure cyclinder and direct from a boiler in close prox-

imity to the steam cylinders; and the additional device for re-heating steam and increasing temperature of feed water, as above mentioned, by waste gases from the boiler furnace, it appears to me that the problem of producing the greatest mechanical effect through the medium of steam by the consumption of a given quantity of fuel, is practically solved without much difficulty.

After the production of motive power by the use of the perfect compound steam engine for a pumping engine, the next step to be considered is the pump or resisting force. This force consists in the exertion of moving a mass of water from a given point to a certain distance or to a given height. To perform this work economically it follows that this resisting force should be reduced to a mechanical operation, requiring the minimum of exertion outside of the actual static lift of the water and the friction of the water in the various pipe connections.

Water may be considered as a mass of weighty matter set in motion by the motor while driven and moved about in the pump mechanism to its final point of delivery, and like all bodies, after the first application of force to give it a regular and continuous momentum, requires but a constant and steady application of force to overcome the regular resistance due to static head and frictional resistance, much as the power of a locomotive is applied to the hauling of a loaded train of cars up a regular and uniform incline.

It therefore follows, that in a perfect pump mechanism, the moving mass of water should never be brought to rest after being set in motion in a certain direction, and especially should it never be reversed in its course, for whatever power is required by the motor in the exertion of starting a body of water in motion in one direction, twice that amount will be required and wasted in reversing its motion. If the water is allowed to come to rest only, the exertion to bring it from its state of rest to its maximum velocity will have to be renewed and the power wasted at each operation.

From the above it will be readily understood why steam and air-cushions, springs and other mechanical devices, are used for reducing the force of impact of surfaces in some pumping engines, and other power-destroying appliances interposed to preserve the mechanical parts from sudden destructive effects due to reactionary forces of the moving mass of water on the pump mechanism.

The effect of springs on water valves is as wasteful in motive

power as a reduction of valve openings, requiring a greater power on the pump piston to overcome the back pressure of such valves. In a perfect pump mechanism the valves should be but little heavier than the water, and provided with smooth, clear bored water passage of non-corrosive metal, and offer no flat contact surfaces to the water passage when opened. They should be free from complication, and of such a form as to be easily and quickly acted upon by the pump current. Where larger metal valves have been used, I have invariably applied springs to counteract their weight, with success. Some twenty-six years ago, while experimenting with a fifty-inch diameter pump at the Brooklyn Water Works, I removed the springs on large brass disc valves faced with rubber, which I had been urged to put on by the inspecting engineer in order to make them close promptly, although the weight of each valve alone amounted to some forty pounds. After removing these springs I found by the indicator diagram fifteen hundred pounds less exertion on the pump piston at each stroke.

In practice I have adopted a five-inch rubber ball valve, confined in a cage and working on a finished brass seat. With the opening bored out three and three eighths inches diameter, they worked admirably at a pump pressure of one hundred pounds per square inch. In lighter pressures this opening may be increased to three and five eighths inches, but the quality of rubber in these balls must invariably be of the best, as a poor quality will split. Only sufficient composition must be added to the rubber to give it a moderate hardness. They must also be very elastic.

I have many years ago experimented with pump valves, the openings and closures of which were either entirely or partially controlled by steam pistons, springs or power derived through mechanisms operated by the motive engine, but found that there always existed a clashing of forces between the pump current itself and the interposed mechanical force, which resulted either in a waste of power, or loss of action in pumps.

If the force of the current during its passage through the valve openings is interfered with, there invariably results a loss of action or of power. Water valves should be constructed so as to offer the least possible resistance to the passing current, and made to yield to it as gently in their resistance of opening and closing as a floating substance upon its surface. When I speak of pump current I mean

the motion of water in the various pump chambers preparatory to its delivery to the force main.

Bélidor recognized the importance of a nearly balanced valve and free water passage, for in his "Machine Hydraulique" he constructed a butterfly water valve almost balanced, making the swinging axis of the disc only sufficiently eccentric to make one side only enough larger than the other so that it would be acted upon by the current for its opening and closure, the valve when open presenting its minimum area to the current. This was certainly a very clever device to reduce the acting area to a minimum and increase the water passage area to a maximum with a free and straight passage for the current. In fact, there are few pumps of to-day that embody such a careful study of the subject as those noble old machines of over two centuries ago.

The next step will be the consideration of the manner in which the motive power is applied to the water for the purpose of raising it from its source or state of rest to the point of delivery at the required elevation. In a perfect pump mechanism the current should not be moved by a series of spasmodic shocks produced by a reciprocating piston or plunger, but after once being started should be kept moving as regularly in the pump mechanism as in the force or delivery main.

Were we to view through a sight glass the starting, then stopping, and continual reversing of currents in the pump chambers and cylinders of the reciprocating pumps of to-day, which are no different in their churning action from those of two hundred years ago, we could easily understand why some engines are brought to a perfect state of rest at each consecutive stroke by means of steam or air cushions, springs or other mechanical power, destroying devices to soften the violent reactions of the water which desires to keep up its forward and continuous course, and is prevented by the imperfect mechanism. The pump mechanism or lifting force should never be applied to the water in an opposite direction from that in which it is moving, but should be designed to keep up its motion in the same direction continually. A pump bucket or plunger should therefore never perform its lifting or forcing function except while moving in the same direction as the current, and should remain neutral or glide through the current with the least possible resisting surface, while preparing itself for the next stroke.

In a true and perfect pump mechanism there should never be less than four buckets or plungers, one of which is travelling at the rate of two or three hundred feet per minute, and the others preparing themselves to return and catch up gradually, in turn to the fourth before its speed is diminished for the return stroke. These motions can be very easily obtained from a double crank or flywheel engine, either by direct connections or through beams.

I would suggest that the pump speed be limited from two hundred to three hundred feet per minute as the most economical. I found by experience that although a well constructed pump can be operated almost noiselessly at a greater speed, yet the friction of the water against the contact surfaces increases to such a degree as to reduce the economy to a considerable extent.

Having advocated a steam piston speed from 400 to 600 feet per minute, and just now a water speed of 200 to 300 feet, we will now see how to combine two elements so different. Practically the beam rotative engine is the easiest solution of the problem, as the beam between its main and end centres affords every desirable speed from maximum to minimum. Thus, if we connect the steam cylinders to the extreme of one end of the beam, the crank and flywheel to the opposite, and the pumps on each side of main centre, half way between it and the ends, we will obtain a speed of 600 feet on the steam pistons, and 300 feet on the pump buckets or plungers, and while the bucket or plunger at one end is carrying with it the current, the opposite bucket is returning, gliding gently through the current to prepare itself to take up and continue the impelling force on the next stroke.

As air pumps invariably require a slow speed we can connect them at a quarter or third of the distance, between the main and end centre nearest the former, thus giving them either a speed of 200 or 150 feet, or less if desired.

In conclusion, I consider that the lifting process is far preferable to forcing, as in the former the driving mechanism moves with the current. Hollow plungers work admirably and are to be recommended, the only disadvantage or objection being the large packing surface.

In concluding this rapid survey of the subject, much of the solid material has been left without giving it its rightful importance, such as the steam generator, mechanical details, etc.

DISCUSSION (by F. W. Dean).

An examination of this paper reveals a great misconception of the action of steam and the trend and *rationale* of modern steam engine practice. The misstatements and exaggeration will tend to do great harm and retard the growth of correct ideas and the installation of better and better pumping engines if they are not met with vigorous and positive denials.

The author of the paper cannot be denied the privilege of worshipping the practice of two hundred years ago; but when he finds nothing to admire in present practice outside of his own creations, he cannot escape censure. He sees nothing to approve in the increased speed of pumping engines, in the use of high steam pressures, and in the perfecting of means of the utilization of the latter. He sees nothing in the extension of multiple expansion beyond two stages, nor in any steam pressure beyond ninety pounds per square inch, which by some occult power have been revealed to him as magic numbers.

The paper is considerably devoted to a discussion of the importance of handling water without deflections or reversals of the directions of currents. It is well to keep these matters in view, but the paper is full of exaggeration of the shortcomings of ordinary practice. The waste of power by interference with straight water currents is represented to be enormous, but when we remember that the efficiency of a pumping engine is from ninety to ninety-five per cent, and that our knowlege of stationary engines shows this to be chiefly made up of engine friction, it is evident that little more need be or can be done to perfect the water end of pumping engines. The "enormous" loss due to reversing water currents is referred to, but this loss is next to nothing on either the suction or discharge side of a pump if suction and discharge air chambers are used. With these provisions the work given up by the water (except a very slight amount of heat generated) is absorbed by the air which becomes compressed and immediately by expanding gives it back again to the water.

Steam jackets are condemned as being useless and wasteful, but too many proofs of their efficiency are at hand to accept such a view. It is sometimes objected by the uninformed that jackets condense steam, when this is just what they ought to do and must do to be of any value. Jackets are for the purpose of supplying heat to the working steam inside of the cylinder, to diminish its initial condensa-

tion, and condensation during expansion. The more the jacket condenses, the more it is performing its function, and great jacket condensation should be welcomed. Professor Thurston has shown that jackets in general save five times as much steam as is condensed in them.

The same argument applies to re-heaters, the difference being that the effect is produced on the working steam after it has left the preceding cylinder. Steam comes from the cylinder in a wet condition, the live steam in the re-heaters, by rapid condensation, gives up heat and dries and super-heats it so that it is in fit condition to do economical work in the next cylinder.

Members may remember the remarkably economical performance of the Louisville (Ky.) pumping engine. In this engine the jackets and re-heater condensed about seventeen per cent of the total steam used. While this is the greatest amount of such condensation on record, the engine is the most economical compound engine on record.

Concerning higher steam pressures than ninety pounds per square inch, it is probably enough to state that the compound engine has reached a degree of economy unanticipated a dozen years ago, and that this has kept pace with a gradual increase of pressures, and that these pressures have long since been beyond the ninety pounds mark.

DISCUSSION (by Asa M. Mattice).

While agreeing with the author that, in general, the rotative type of engine is the only one which should be seriously considered for water works use, I must take exception with him on a number of points.

First, the steam pressure which he advocates, viz., eighty to ninety pounds, can hardly be considered modern. The practice of the day has so conclusively proven the advantage of pressures more than double those mentioned, that comment on this point seems hardly necessary.

Then, his substitution of a non-conducting covering of asbestos, *instead of the steam jacket*, can only arise from a complete misunderstanding of the functions of the latter. One might as well say, that the possession of an overcoat supersedes the necessity for food. If the function of the steam jacket were *the prevention of radiation*, then the use of the steam jacket would be foolish in the extreme, for the steam jacket not only gives a greater radiating surface than the

unjacketed cylinder, but it offers a surface which is much hotter than the average temperature of the cylinder. The non-conductor is as essential in the one case as in the other, but all the non-conducting material in the world, if put on to one cylinder, would not *transmit heat to the expanding steam* as the steam jacket does. So much has been written on the theory of the steam jacket that a dissertation on the thermo-dynamics of the subject would be but idle repetition. What users of steam engines need to know is the practical result. A great many results of tests with and without steam jackets have been published from time to time, but the reports are so widely scattered throughout various technical journals, that they are not readily available to the average steam user. But so much of this literature has been collected in one little book, that I must call attention of our members to "*The Steam Jacket*" by Wm. Fletcher (Whittaker & Co., London, 1895). There is hardly a word of theory in the whole book; but the auther gives numerous examples from practice, relative to the use and abuse of the steam jacket, details of various tests, etc. He gives in tabular form the results of no less than sixty-one tests which have shown high economical gains from the use of the steam jacket, on the authority of such experts as Donkin, Emery, Unwin, Farcot, Hirn, Mair-Rumley and others. He gives examples, from actual practice, showing some of the defective jackets which have been from time to time cited as showing their uselessness. Some of these show nearly as great a misconception of the function of the steam jacket, as that in the paper under discussion. The book mentioned, which costs about two dollars and a half, should be in the hands of every water board about to invest in an engine.

The author's denunciation of re-heating by live steam may be classed in the same category with his lack of appreciation of the steam jacket, for the principles involved are practically identical, and the pudding has been abundantly proven by the eating. Re-heating by flue gases, as advocated by the author, has often been tried with good results as to duty, but the apparatus has generally been costly in the matter of repairs. There is one thing that can be said of live-steam jackets and re-heaters, when properly made, which cannot be said of many parts of an engine, and that is that they pay large returns on the investment without appreciable cost for repairs, and with next to no attention.

The author states that in a perfect pump mechanism the moving mass of water should never be brought to a state of rest after being once set in motion. I do not believe that there is any other matter connected with pumping-engine designs on which so much time has been wasted by inventors as this. The number of inventions said to produce the desired result rivals that of inventions for producing perpetual motion. The fact is too often lost sight of that in a reciprocating pump, whether direct acting, or of the flywheel type, the piston or plunger *must come to a dead stop* at each end of the stroke, and that, in order that the suction valves may close, the water, too, *must* come to a stop. And after once coming to a stop it does not matter whether it be set in motion in the same or the opposite direction. It is beyond the power of the designer to do more than bring the water to a state of rest and start it again with as little shock as possible, and to keep down the velocity of the water in the pump chambers, regardless of the velocity of the plunger.

The loading of pump valves by weights or springs, decried by the author, is an evil which should be eliminated from pumping engine design if possible. But it is a question of a choice between several evils. First, to increase the pump resistance by these weights or springs; second, to close the valves by independent mechanism; or, third, to eliminate the weights, springs, or mechanism, and incur a greater loss by slip. It is better to lose, say, two per cent by spring loaded valves, than to lose four per cent in additional slip, due to sluggish closing of the valves. I do not see how the ball valves advocated by the author can possibly solve the difficulty. Unfortunately, the matter of weirs, Venturi tubes, or discharge cones, for measuring the output of pumping engines, does not receive the attention from water works managers that it should, and it is, therefore, impossible in most cases to say what proportion of the dollars is lost in excessive slip. If we could place two engines side by side, one with loaded and one with unloaded valves, the relative plunger displacements of the two engines, working on alternate days or months, would give some information on the subject, even without accurate measuring devices, although the latter would be preferable. It so happens that at Lynn, Mass., there is such a case, viz., one engine with heavy cast-iron valves and one with rubber ball valves. Sometimes one engine runs and sometimes the other. The reports of the Water Board show that in five years the iron-valve engine

ran 527 days and the ball-valve engine 1,051 days, which periods are sufficiently long to eliminate any ordinary errors. Taking the number of revolutions given by the reports, and the sizes of the plungers, it appears that the average daily plunger displacement of the ball-valve engine is more than nine per cent in excess of that of the iron-valve engine; from which it follows that the good people of Lynn must be nine per cent thirstier when their water is pumped through ball valves, or else that the unloaded ball valves give that much more slip. The latter appears to be the more likely. If we take the performances of the two engines for succeeding months we find a similar difference in slip, but the five-year average is a better proof. Of course, the loading of valves can be overdone, but it can be carried to a considerable excess without producing as great a loss as would be produced by slip with the unloaded valve.

The advisability of not less than four plungers, and the limitation of the plunger speed to 300 feet per minute, both advocated by the author, are not proven by practice. Take, for instance, the Calumet and Hecla Mining Company's engine "Ontario," with two plungers, 5 feet stroke, worked by a *single crank*, and running 38 revolutions per minute without shock. One of the easiest running pumping engines I have ever seen is the *single crank* engine of the Barmen Water Works at Volmarstein, Germany. I have seen this engine, of 43 inches stroke, run 63 revolutions per minute (a piston speed of 450 feet per minute) against 750 feet head, without perceptible shock.

The author very pertinently calls attention to the fact that high duty should not be attained at such a high first cost of engine, that the investment is not a profitable one to the capitalist. This question of high duty and first cost is one that is too often not properly considered by our water works officials. In this connection, I would call attention to the report of the Louisville Water Company, for the year 1895, to show the possibilities of the compound pumping engine. From this report, it appears that the duty of their engine for the entire year, using Pittsburgh coal (which is much inferior to our Eastern coals), and counting all coal used at the station, was 124,395,952 foot pounds per 100 pounds of coal. The report adds, "The coal was not housed; was exposed to the weather in out-door piles, from which it was taken, weighed and passed into the furnaces, wet or dry, and charged to the engine without deduction for

moisture, cinder, clinker, or ashes." I cannot find that this duty has ever been equalled, even by triple-expansion engines. And in this Louisville engine, by the way, are embodied nearly all of the features which the paper under discussion classifies as disadvantages; the cylinders are steam jacketed, there is a live-steam re-heater, there are but two plungers and one crank, and the valves are heavily loaded by springs.

But, to return to the question of first cost, I would like to call attention to the accompanying table, prepared by our late Secretary, Mr. R. C. P. Coggeshall, Superintendent of the New Bedford Water Works, to assist in the choice of a couple of new pumping engines. From this table may be found by inspection the relative prices which could be paid for engines of various duties in order to give the same return on the investment. The table gives the figures for various duties progressing by ten million foot pounds, but any intermediate figures may readily be found by interpolation. It will be seen that for an engine to pump ten million gallons daily at the same duty as the Louisville engine, or 124 million foot pounds, they could afford to pay $47,000 more than for an engine which would give only 100 millions duty. They now have at New Bedford a direct-acting engine with "high-duty" attachment, which has given a yearly duty of a little less than 86 million foot pounds, but let us call it in round numbers 90 millions. It will be seen directly from the table, that for an engine giving 120 millions duty they could afford to pay $67,250 more than for an engine of their direct-acting "high-duty" type giving 90 millions duty. As each of their new engines has been contracted for at a cost of less than $75,000, including engineering expenses, it follows that a direct-acting engine would have to be sold to them for about $7,750 in order to be a good investment, which is very considerably less than they would be likely to get a ten million gallon engine for! Let us compare, also, the cost of the high grade engine with one of the direct-acting compound type without high-duty attachments, such as are often used in water works on account of low first cost. There is no authentic record of any engine of this type having given a duty as high as 60 million foot pounds. But, supposing that duty to be obtainable, the table shows that $202,000 more could be paid for an engine of 120 millions duty than for one of 60 millions. In other words it would pay better to buy the more expensive engine *than to have the compound direct-*

TABLE showing annual cost of coal for pumping ten million gallons of water daily to a height of 170 ft. under different rates of duty, with coal at $3.75 per ton of 2,000 lbs. The table also gives sums the interest of which at 4% represents the saving effected by an engine of superior economy over an inferior one.

Select the column headed by the higher duty. Then select the line beginning with the lower duty. The sum found at the intersection of the column and line is that which, at 4% interest, could be paid for the higher duty engine above the price of the lower duty engine.

Lower duty, in million foot pounds per 100 pounds of coal.	Pounds of coal required to raise ten million gallons of water, 170 ft. in 24 hours.	Cost of coal for 365 days at $3.75 per 2,000 pounds.	HIGHER DUTY, IN MILLION FOOT POUNDS PER 100 POUNDS OF COAL.									
			150	140	130	120	110	100	90	80	70	60
50	28,360	$19,410	$323,500	$314,000	$298,750	$283,000	$264,750	$242,750	$215,750	$182,000	$138,750	$81,000
60	23,630	16,170	242,500	233,000	217,750	202,000	183,750	161,750	134,750	101,000	57,750	–
70	20,250	13,860	184,750	175,250	160,000	144,250	126,000	104,000	77,000	43,250	–	–
80	17,720	12,130	141,500	132,000	116,750	101,000	82,750	60,750	33,750	–	–	–
90	15,760	10,780	107,750	98,250	83,000	67,250	49,000	27,000	–	–	–	–
100	14,180	9,700	80,750	71,250	56,000	40,250	22,000	–	–	–	–	–
110	12,890	8,820	58,750	49,250	34,000	18,250	–	–	–	–	–	–
120	11,810	8,090	40,500	31,000	15,750	–	–	–	–	–	–	–
130	10,900	7,460	24,750	15,250	–	–	–	–	–	–	–	–
140	10,010	6,850	9,500	–	–	–	–	–	–	–	–	–
150	9,450	6,470	–	–	–	–	–	–	–	–	–	–

acting engine presented to them, with the addition of a bonus of about $125,000 thrown in. These figures are for ten million gallons daily capacity. For a smaller pumpage rate they would be correspondingly smaller.

If our water works authorities would look into the question of first cost as thoroughly as they did at New Bedford, we would see a good many dollars saved. It is a very easy matter to get up a table similar to Mr. Coggeshall's to suit any case, simply by substituting the pumping capacity, feet head to be pumped against, and cost of coal, according to local conditions.

Moreover, as a general thing, a part of the cost of high grade engines — I may say a large part of the cost — goes for high grade material and workmanship, which is offset by less cost of repairs, although these items of cost have nothing to do with the increase of duty. The old McAlpine engine at New Bedford is a fine example of this. Although built in 1869, it is now, *after twenty-seven years running*, their "old reliable," and with 30 pounds steam pressure it gives a duty only fifteen per cent less than their compound high duty engine built twenty years later and running at 110 pounds pressure.

In conclusion, I would refer to a side of the question which is too often neglected — the æsthetic side. In water works construction we find much money spent to please the eye. We find elaborate cut stone work about reservoirs, where very rough construction would suffice. We find elaborate gate houses, where shanties would afford all necessary protection. We find the grounds artistically laid out, with well-kept lawns and walks. We find the buildings at the pumping station of ornate architecture. But when we open the engine house door we find, too often, a veritable nightmare of engineering construction. Now, whether we have a high duty or a low duty engine, steam jackets or no steam jackets, valve springs or no valve springs, four plungers or one plunger, why not let the engine be in keeping with the other works, and spend a little money to make it as pleasing to the eye as the buildings and grounds?

DISCUSSION (by the Author).

After a perusal of Mr. Dean's discussion of my paper, I fail to find "vigorous and positive denials" of facts given. That the general principle of pump mechanism of over a century ago are the present day's practice stands still an undisputed fact.

The writer's experience of thirty-five years was thought to entitle him to present some suggestions to the members of the Association. Having outgrown the wisdom of youth, I desired to pay tribute where honor was due, namely, to the originators of the pumping engine.

I have advocated a steam piston speed of six hundred feet per minute and a water speed of three hundred feet, which shows my approval of increased speed in pumping engines, notwithstanding the two hundred feet limit of ordinary practice among direct acting pump builders.

The fact that the highest attainments in pumping engines can only be reached by a quick steam piston combined with a moderate water piston speed of three hundred feet per minute remains yet unanswered, as is also the handling of water against weighted valves explained according to my experiments on the Brooklyn engine some twenty-six years ago.

As to the benefit from higher steam pressures, he fails to explain why the old Holland and Cornish engines, built nearly sixty years ago, give such a magnificient efficiency. A single cylinder Cornish beam in the United mines developing an average duty, in 1842, of 114,361,700, with less than 20 pounds boiler pressure, while to-day, engines with 125 or even 200 pounds boiler pressure can hardly be compared with it in efficiency.

As to the subject of re-heating steam, but little light has been thrown on the subject of my suggestion, — that it may not be best to reheat the steam, while on its passage from high to low pressure cylinders, by live steam coils at extra fuel cost, rather than by waste gases escaping to the stack.

Mr. Mattice states in the second paragraph that comment on the point of very high steam pressure is unnecessary, and that a moderate pressure of 90 pounds is hardly modern, yet he concludes his discussion by stating with reference to a compound engine: "I cannot find that this duty has ever been equalled, even by triple-expansion engines." As this latter seems to contradict the assertion in his second paragraph, further comment is superfluous.

No one doubts the efficiency of steam jackets in the absence of other re-heating devices. From the moment steam leaves its generator to perform its function on the steam piston, it evolves heat, and the greater the pressure, the greater the capacity for throwing off heat derived from the coal pile. The natural conclusion would there-

fore follow, to reduce the distance of its travel and prevent, by artificial means, this evolving of heat called radiation. To perform this act by means of additional fuel, when large masses of gases at an average temperature of five hundred degrees are wasted up the stack, seems unpardonable.

Surely, no one will dispute the fact, that even steam jackets and coils are used to keep up the life of steam before final action, and that they in turn must be thoroughly protected by asbestos from evolving their heat, excepting into the walls of the steam cylinders. Now, if the heat evolved by jackets to working steam can be dispensed with, and a greater degree of heat imparted thereto by waste gases, why should such objection be raised to the device, especially when it can be performed at the saving of fuel?

The objection raised by Mr. Mattice that such an apparatus for heating steam by waste gases is costly in the matter of repairs, is no argument against the principle, it being then only a question of mechanical ability to apply the principle

There appears to be no prettier motion for the opening and closing of a valve than that imparted to it by the current of the water as the engine passes the dead centre of the crank, giving that gradual increase and decrease in lift coincident with the approach and departure of a circle from its tangent point.

Let us suppose that four buckets of the Cornish type were operating, one above the other, in one long vertical cylinder, and that each received its motion from the opposite ends of two beams of a duplex engine; there would always be one bucket raising the current in the upright pipe at the maximum piston speed, imparted by the circular motion of the crank between the second and third quarter motion of the semi-circular crank movement of the up or down stroke, as the case may be.

Now, it is evident that the four buckets which are actuated by four different movements of the rotative motion of the crank-shaft, are so raised with regard to each other that there will be one invariably moving in an upward direction at its greatest speed, while the other three are idlers, and preparing to catch up to the fourth, allowing their valves to open or close gradually during a period of one fourth of the entire revolution of the engine. This is what the author considers an ideal pump.

The Lynn engine may embody indirectly, to a certain extent, such a principle, yet is far from being an entire ball-valve pump, large

heavy metal valves being there in use. Nor is this criticism relative to the slip of the large Lynn pump considered fairly when compared with the smaller one; for, when the larger one is in operation, considerable water is used to operate a dynamo for incandescent lights about its surroundings. Yet, even then, when one considers that the cost of that engine was less than that of the smaller one with only one half of its capacity, allowances may be made for slip and duty.

The author does not and never has advocated too low-priced pumping engines, but is a strong believer in the happy medium. Simplicity, durability and efficiency, combined with a pleasing exterior, ought to be the aim of builders, while the first cost should not be too great.

For instance, a 10,000,000 gallon engine that costs $35,000 with an average duty of 110,000,000, is certainly cheaper than a 5,000,000 gallon engine at the same price, which develops a duty of 120,000,000.

Then again, all engineers know how perfect the management of all high duty plants must be, and that the best mechanics are needed to operate them and not the cheapest, which also involves quite an additional annual expense not taken into consideration in the discussion.

If a 20,000,000 engine can be built for $75,000 and develops a duty throughout the year of 120,000,000, and requires but ordinary attendance, such an engine is preferable to one that costs $175,000 and develops a duty throughout the year of 130,000,000 and requires extra help and special mechanical skilled attendance.

When an investment is made in a plant, the annual coal pile required to be supplied and the pay roll are the important factors to be considered, with the interest of the cost of the plant. A duty developed with hand-picked coal will hardly be a satisfactory test as to the quantity and quality of coal required during the year for a certain amount of water delivered into the reservoir for distribution.

THE PROTECTION OF SURFACE WATERS FROM POLLUTION.

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[*Address, Dec.* 9, 1896.]

Within the last few years I have had occasion to investigate various outbreaks of typhoid fever, and in the course of these investigations, covering now some fifteen epidemics, it has been gradually more and more impressed upon me that too little watchfulness is exercised, in many cases, to prevent the pollution of surface waters. It is true that we have had, in Massachusetts, ever since 1878, an excellent law forbidding to a certain extent the pollution of rivers and other streams, and this law is well enforced. But I do not now refer so much to the more gross and obvious pollutions, as rather to a class of what I might call minor or temporary contaminations. These fall chiefly under two heads, namely: —

1. Pollutions due to permanent residents on the watershed.

2. Pollutions due to temporary residents, — such as laborers engaged in constructions, additions, or repairs, and to visitors, — such as fishermen, picnickers, and the like.

I will explain exactly what I mean by two illustrations of each class, — two drawn from my own experience and two from the experience of others.

One of the best examples of danger from the pollution of surface waters from regular residents on the watershed is the famous Plymouth, Penn., case. This is too familiar to need detailed statement, but briefly was as follows: —

The town of Plymouth, Penn., had a water supply obtained by damming up a stream, and on the upper part of that stream, above the reservoir, was a resident family, which for many years had been in good health. During a certain winter, however, — I believe it was 1885, — some members of the family fell ill with typhoid fever, and the excreta from the patients were thrown out on the snow on

the watershed. There they remained during the winter, but when the spring thaws came they were carried down into the reservoir, and in this town of some 8,000 inhabitants there occurred within a very short period about 1,200 cases of typhoid fever. Of course, the reservoir was a relatively small one, and the contamination was therefore very direct. But it was a case in point,— that is to say, it was the pollution, sudden, unexpected, unusual, from a family of permanent residents on the watershed, a pollution which was carried directly to the water supply and eventually to the consumers.

A similar case I was myself fortunate enough to witness, namely, that of Windsor, Vt., two or three years ago. This case was very similar to the Plymouth case, except that the cause was not quite so clear. Windsor, Vt., is a comparatively small town, and had dammed up a brook in a narrow gorge, and made a long, narrow, and not very capacious reservoir. On the upper end of it were a few houses, or rather on thes tream leading directly into it, and in one of these houses there was found a case of illness as to the nature of which the physicians disputed more or less; but to the satisfaction of at least the health authorities of Vermont, better to their satisfaction than to my own, I must admit, it was claimed to be undoubtedly typhoid fever. Connected with this house was a common privy, which was flushed out by the melting snow, and the contents of which were carried down into the brook and from the brook directly into the reservoir. The reservoir being small, it was to be expected, as happened, that the people suffered immediately and very seriously. There was abundant evidence that the water was infected, and there was reason to believe that the original case was probably a case of typhoid fever, although the facts were not as clear as they were in the other case, or as clear as could have been wished. There was no doubt whatever that the typhoid fever came from the water supply, because facts like this, for instance, existed: Windsor is the seat of the State's prison, the prison being supplied with a different water, and there were no cases in the prison among the large number of prisoners. I think there was one case in the prison but it was the wife of the keeper or someone who had been out and about and had drunk water elsewhere in the town. The prisoners were wholly unaffected, while the people in the town, the ordinary water consumers, were very heavily stricken.

The epidemic of typhoid fever in Providence, R. I., in 1888, was

traced by the health officer, Dr. Chapin, to a similar origin to that in Plymouth, Penn., and there are many other examples on record.

It appears to be true, then, that while permanent human habitations on a watershed may for years do no damage whatsoever, they do, nevertheless, constitute a permanent menace to the purity of the waters collected in their vicinity. It is no sufficient answer to say, "We have had houses on our watersheds draining into our water supply for many years and have never had any trouble." That may be very true, but the reason may be merely that these particular families have never during that time happened to be infected with typhoid fever. The blow may yet fall at any moment.

We turn now, in the second place, to the other class of cases of pollution which we have to consider. And here I shall begin with the well-known Caterham case, giving thus first an example from foreign experience and then one from my own.

This Caterham case occurred in England, in the village of Caterham and Red Hill, in 1879; and it is particularly instructive, I think, for water works men, because it illustrates a source of danger which they are apt to forget. Caterham and Red Hill had been growing, and they wanted more water. In this case water was derived not from the surface, but from wells in the chalk, and the officials started in to make a new well to give them an additional supply. In the course of the digging of this well, the instructions were that any workman who had to defecate should either go up in the lift to the surface and use a privy there near the mouth of the new well, or else, in case he could not do this, should use a bucket below which was kept for that purpose, and which was occasionally hauled up and emptied. Things went on well enough for a while, but all of a sudden a very serious epidemic of typhoid broke out in Caterham, and to a less extent in Red Hill which got its water from the same source. A careful investigation showed there was pollution of the water supply, and still further investigation showed that at the time when the new well was just being completed, and connection between the old well and the new was about to be made, one of the workmen had had what turned out afterwards to be probably typhoid fever. That is to say, he had complained of feeling "run down," "played out," "dragging around," and had had diarrhœa and, no one watching him particularly to see that the rules were carried out, as he admitted afterwards, he had been in so much haste that he had n't even waited to

use the bucket, but had defecated right in the bottom of the well, and when he had used the bucket it had been generally full and running over at the top, so that as it was lifted up out of the well, it used to slop over more or less; and all through the investigation it was perfectly evident that things in that well were not as they should have been. Moreover, the date of this man's illness, which would answer for the seed, and of the crop of cases which appeared below among the water takers, corresponded. The cases appeared nowhere else, excepting in one rather amusing instance, where a family had been stealing water, having made connection surreptitiously with the company's pipes. There were a number of cases in this family, and at first it was very puzzling to the medical officers; but when they found out that a pipe had been connected without anyone knowing of it, and that the family had really been getting the same water as the other victims, it seemed that good, heroic justice had been done them.

That was in 1879, and, though upon a ground water supply, illustrates very well an important point in this matter, which is the care that needs to be taken in *repairing* or *adding to* an existing supply. There are, as I shall show, conservative features in these cases. If your reservoirs are large enough they may be seriously contaminated at one end, and yet safe to drink from at the other, as is the case in Burlington, Vt., where raw sewage is put into the lake at one point, while the water supply is drawn from another; and as is the case in many other of our lake cities, such as Buffalo, Cleveland, Chicago, Milwaukee, and Duluth. But, at the same time, it is not good practice to drink from one's own cesspool, and if one must drink from it, he must be careful to drink from the other side, and not from the same side into which he puts his sewage. But if he does not know that he has a cesspool, and supposes that he has a good surface water, still, in making additions to that supply, and having a lot of workmen about, he needs to be very careful. It often happens that the population employed in making additions or repairs to a water supply is as large as that of a small town, and no superintendent would feel comfortable if he knew that a small town were suddenly planted directly upon his watershed, where he had n't suspected its existence before. Yet the same superintendent sometimes forgets that in keeping large gangs of men there six months, or even three months, or even three weeks, he may get into very serious

trouble. This Caterham case was a good illustration of that, because it was traced directly to a workman so employed.

I may now give a similar case from my own experience, and affecting surface water. Several years ago, a new reservoir was under construction for a large and important American city. It was, when done, to be connected to an existing system of reservoirs, and during the work of stripping and dam-building, large gangs of men were employed. The stream which was to be dammed up, naturally ran through the valley where these men worked, and on into the lower reservoir. An epidemic of typhoid fever broke out among the workmen. I was called in to study the *cause* of this epidemic, but I very soon saw that interesting as that study was from a scientific point of view, the possible *effects* of the epidemic were practically far more important. I was sent there to find what the cause of the typhoid fever was, but this question had to wait while I tried to prevent the typhoid germs produced by the people who were working on this brook and using it as their drain, from reaching the consumers of the water after they had got into the reservoir below. So I abandoned very quickly my original hunt, and went after another and far more important kind of game. There were hundreds of men at work, and quite a number of them suffering with typhoid fever, all about or very near the brook. Many of them were visibly using it as a drain, and a defecating place, for they could be seen to retire into the bushes right on the shore of the brook; and among these men I knew a certain percentage had typhoid fever, while the brook was running directly into a reservoir to be used for drinking. Fortunately, the reservoirs were so arranged that this one could be disconnected for a time; earth closets were put in, disinfectants employed, and every possible precaution that we could devise was taken to prevent further trouble. I am happy to say that our efforts were entirely successful.

I believe that these cases are a good deal commoner than we know, and I believe it is a subject that a water works superintendent needs to keep constantly in view. As a rule, to be sure, he is not the man who has most to do with it. The work is put out to contractors, and the superintendent, perhaps, is busy around the town or city which he serves, looking after the piping, while laborers by the hundred it may be are at work on the watershed, perhaps polluting the water supply in a very serious way.

In this connection I want, also, to speak of the dangers from fish-

ermen, bathers, picnickers, boatmen, and summer cottagers. And first, as to fishermen. It is a fact, as you all know, if you have large reservoirs that contain good fish, that there is a great desire among certain people to fish on your reservoirs. There are two kinds of fishermen, those who go out in boats and those who fish from the shore. Now it often does not take a great deal of inspection of the shore of any reservoir which is also a good fishing pond to find evidence that it is used as a kind of privy. I have seen instances of that kind, one not very long ago, where within a comparatively few feet of a gate-house, I saw a considerable number of evidences of defilement of the shores, what might be called shore defecation. That comes, of course, mainly from people who go out for a day's sport, as they call it. They are not always careful to empty their intestines before they leave home, and even if they are nature may make another call, and then they are not at all particular to go off the watershed. Of course, the majority of these people are healthy, and what they leave is simply filth. But among them, now and then, if you take a large percentage of people, there are sure to be some persons in the early stages or having mild cases of typhoid fever, and if Asiatic cholera were to visit our country there might be some affected with it among such people. I grant that the danger is not very great, but it is one of the things to be afraid of, one of what I have called the minor dangers. None the less I believe it to be a real one, and I have myself seen abundant evidence that it exists in fact and not merely in theory. Anyone who will take pains to look and will inquire into the class of people who produce the deposits, will very soon satisfy himself that in some cases, at any rate, these involve grave dangers.

Then there are the fishermen who go out in boats and do not stick to the shores. Their boats are very often of the heavy, broad-edged type, and fishing often lasts through the night. It is not at all uncommon for men to fish all night after eels, for example. I know what I am speaking about on this matter, because I have actually looked into it; this is not theory, it is fact. Men do often stay out over night on ponds, and sometimes on reservoirs. And when they do, it is not at all unlikely that they sometimes make use of the edge of the boat as a convenient seat, and contaminate the water. Now if it happens that just at that time the boat is over the upturned end of the in-take pipe, and if it further happens that the fisherman is in

the early stages of typhoid fever, — these I admit are remote possibilities, nevertheless they are possibilities which ought to be guarded against by any one who is looking out for everything, — then there is here opportunity for contamination. In my judgment no water supply should be used as a fish-pond or for purposes of entertainment. That is not what it is made for. It is intended to provide good water to put inside the alimentary canal, and it must not be allowed to serve as a convenient place into which to empty the alimentary canal.

Next, there are picnickers. Nothing is more attractive for picnics than the shore of a well-kept reservoir, but if you will investigate picnic places you will find that privies are not always present, and that the bushes near the shore are resorted to a good deal. If there are privies there they are often in such a position that they can be flushed out by the rains and emptied from beneath more or less directly into the lake or pond. That has happened more than once in this State and is still happening. Then, of course, among the picnickers are fishermen who use the shore or use boats. There are also those who go simply for the boating or sailing, though they perhaps do not generally stay as long. A new and pressing sanitary problem is coming up in connection with the picnicking encouraged by the electric and suburban railways which are establishing at convenient points "grounds," "parks," "casinos," etc., in order to increase the number of their passengers. In some cases these are very large establishments, and in all cases they are used by a varied and ever-shifting population. On no account should such establishments be allowed to fix themselves on the shores of lakes or reservoirs used for public water supplies, since the general character of a picnicking population is such as almost to make certain more or less shore defilement, boating, fishing, bathing, and the like, to say nothing of the problems of sewerage entailed by such aggregations. A picnic ground with an average attendance of one thousand a day may be, for various reasons, more objectionable than a fixed town of equal population at the same point.

Then there are the summer cottagers. They always like to put their houses right on the shore of a beautiful lake, which perhaps is used as a water supply, and if they do, their drainage must be got rid of somewhere. Of course it does not often go directly into the water; it may or may not go indirectly. That is a thing to be looked after.

And the matter of bathing. Of course, nothing is more tempting than a plunge into a cool, clear lake on a hot summer day. But the time when we bathe most, along in August for instance, is just the time, also, when typhoid fever is most common among our people, — not when the deaths are most numerous, but when the cases are beginning. And these early cases, before people know that they have the disease, walking or other mild cases and so on, are such as are liable to lead people to take a day off. There is nothing commoner, when inquiring into the history of a person who is down with typhoid, than to find that he left his business at first and went off for two or three days to rest, thinking he was a little "run down" or "played out," and that if he could only get a little rest he would be all right. At such times he is very apt to resort to a lake or some similar place, to rest on the shore or to rest in a boat out on the lake; and in the course of that resting if his diarrhœa happens to come on, he being about to come down with typhoid fever, as may very easily happen, of course there is danger. I am allowing that these are minor dangers; I am not pretending that they are as grave as those from drinking from a highly polluted river; but these are things that are to be looked after; and it seems to me that an Association like this, that is well aware of the more serious dangers, ought also, in New England where we hope to have the best of all these things, to have its eyes open for the little dangers as well.

But you will naturally ask, Why, if these things are so, have n't we had more trouble than we have had? The answer is, that all such contaminations are small in quantity; that the opportunity for dilution, sedimentation, purification by light, and so on, is great; as witness, Chicago, and Burlington, Vt., and the other places I have mentioned. Yet we probably have had trouble and have not known it. I have reason to think that I have seen one or more instances of the kind, where, for example, there was a mild epidemic of typhoid in a city, and where, after examining carefully into the milk supply, and into the ice supply, and into everything that anyone could think of, I have finally discovered that the fever spread out from the mains of the water works. When I came to plot the cases these pointed towards the water works. On looking at the reservoir I could not, at the moment, find anything, but I did find that the shore had been used as a sort of amateur privy, and that numerous boats were drawn up on the shore and lay there all ready for anybody to

get into and go out fishing, it might be right over the in-take. I say I have seen cases of that kind, and in one case I was led to attribute the trouble directly to that source.

The whole problem turns, of course, on the life of disease germs in water. And here we are very much in the dark. It is a very reassuring thing to open a book and read that Professor Blank or somebody else has experimented and found that typhoid germs will live only twenty days, or sixteen days, or two months, or something of that sort, in water. The only trouble is that if you open books enough you will find that no two people agree about it. Some will say they will live a few weeks and no longer; others have found that they will live for months. Some have found that they will live in ice; some have found that they die in ice. The only safe ground to take at present is that we don't know very much about it. We know that in laboratories, in glass dishes and so on, under certain special conditions, certain good men have got certain results. These results are valuable, but they do not enable us at present to say with absolute certainty that if we know that typhoid germs went into a certain reservoir on a certain day, three weeks or six weeks from that day we can drink the water with impunity. We don't know that at all. We know very well that most things keep better on ice than they do in the open air. It is possible that the very coldness of a winter night, for example, preserves the life of these things. Cold does not kill protoplasm as heat kills it or as boiling kills it, and the only safe ground for us to take at present in regard to the life of these germs in water is that we don't know much, if anything, about it. That is the ground I have taken and I believe it is the only safe ground. We are making experiments, and various observers are making experiments, and in time we shall know more. But at present the safest way is to keep germs out of drinking waters; but if they get in, to give just as much time as possible before the water is used, and if the time is short to issue a warning. If it is not very short it may be a fine point to decide whether it is necessary to issue a warning or not. That is a thing nobody but an expert can tell, and he must know the local conditions and be familiar with what has gone on in other cities, such as Burlington, Vt., Chicago, and so on.

The gist of all this is, then, that the ideal watershed would be one without any human being on it,— without any *human* being. We do not believe that the birds that fly over drop in typhoid germs. But

what we do know is that trouble has come in certain cases from human beings. We know also that human beings are essentially dirty, especially those of the lower orders. And we know further that when people are a little sick, in the early stages of various diseases, they are apt to take vacations, and go and camp out on a lake or something of that kind, perhaps feeling not sick enough to go to a hospital, or because they don't want to work. So that putting all these things together, from what I have actually seen in the last few years, I have felt that there was a point here. That aside from the gross pollutions which everybody here has learned by this time to guard against, there are these smaller points, these minutiæ, to be looked after; and that the presence, temporary or permanent, transient or constant, of any considerable number of human beings on a watershed, or even of a small number of human beings on a watershed in such a position that their excreta can in any way reach a surface water, is in itself matter for grave anxiety and concern. It may not lead to any trouble whatsoever. If the pond or lake is large and well aerated and well lighted, and the consumption of water is small in proportion to the volume; if the point of possible contamination is very remote from the outlet, etc., it may very likely happen that no trouble whatever will come. But, on the other hand, if it is merely some little brook dammed up in such a way that rapid consumption or a sudden change from one supply to another might draw it down rapidly, then it is a matter of very grave concern if that supply becomes contaminated.

I have seen, for instance, within a few months, such a small supply as I speak of made by simply damming up a little mountain brook, forming a little reservoir only eight or ten feet deep, and hardly bigger than this room, and on the bank of that reservoir a house so placed that the roof-water must about necessarily, in time of heavy rains, flush out the privy and wash the contents directly into this little pond only a few feet away. Now such a condition of affairs, while it looks well enough, a pretty house, pleasant people there, beautiful country, and all that, such a condition is not allowable in the present state of sanitary science, because there is a possibility there that something shall be washed into the water supply, and if so washed in, the reservoir being small, the consumption must be quick, especially if the supply should be heavily drawn upon by a fire or anything of that kind, and the result would be that the contami-

nation would get, while very fresh, to the consumers. That is the one thing to dread, that the germs shall pass quickly from one intestine to another. If they are long on the way they generally die out, we believe, or at least disappear in some way. But any means whatsoever by which they can move quickly from one intestine to another is fraught with danger to the second intestine.

I want to repeat that I do not wish to be understood as claiming that every water supply in New England is in danger because there is a farm house on the watershed. I only mean, that if there is a farm house, even one farm house, on the watershed, that fact ought to be known by the superintendent; and he ought to know whether there is a little rill running down from the back door, and leading off into his water supply. I want especially also to emphasize the fact that the presence of laborers in repairing or extending a water supply constitutes a pretty serious danger, more serious, probably, then the one I have just mentioned of the existence of houses on the watershed.

Discussion.

Mr. Hazen. The watersheds feeding our reservoirs are often used as cow pastures, and cows wander around the ponds, and leave their droppings in various places. I would like to know if Professor Sedgwick has ever made any study of this question, and whether he ever knew of typhoid fever, or other diseases, being caused by the droppings of cows or other animals?

Prof. Sedgwick. I have not, Mr. President. In the present state of our knowledge and belief, the present state of our ignorance I ought perhaps to say, we do not believe that typhoid germs can come from the lower animals. There are some diseases which we believe may come from the lower animals, tuberculosis, for example, and there is such a thing spoken of as typhoid fever in the horse. But there is no case I know of recorded where there is any reason to believe that the droppings of cows, or of any of the lower animals whatsoever, have produced typhoid fever. I think if that were not so we should have a good deal more typhoid than we now have, because there is hardly a surface water about the country that does not have more or less cow dung in it. It is a favorite habit of water works superintendents, in order to make things look pretty, to manure the banks of their reservoirs with cow dung, and there is no doubt that it helps the grass, but there is also no doubt it lets a good many of

the so-called fæcal bacteria into the water. I am not one of those who holds that the presence of fæcal bacteria, such as are commonly found in the lower animals, as well as in man, in a water supply testifies to the presence of human excrement. It may very often, and does, of course, testify to the presence of excrement of some sort, but not necessarily human excrement. And I am very glad to make that statement, because I think there are some bacteriologists who, whenever they find an intestinal bacillus in a water supply, hold that that is *prima facie* evidence of human contamination. I do not see how they can do so, because it is well known that many of the lower animals contain these same germs, or germs not readily distinguishable from our own. We haven't our own private bacilli in our intestines, but we are like the lower animals, our relatives, in having these particular parasites, — which perhaps are not parasites but messmates. I do not believe that there is any evidence whatsoever that cow droppings or horse droppings are able to produce typhoid fever or any other disease that we know of.

Of course, that is a comforting fact, because we unquestionably take in every day, or nearly every day, more or less of these things, either in water or in milk or in the dust of the street. Anyone, for example, who goes upon the Back Bay on a dusty day, and faces one of the dust storms that disgrace our city, has his lungs feeling like a dry furnace box, and undoubtedly hundreds — I know whereof I speak, because I have made examinations of the air — hundreds, and even thousands of these bacteria from dried up horse dung get into our mouths, and some of them into our stomachs. But it is not thought that any of these are likely to produce typhoid fever. The only source of typhoid fever known to-day is the intestine, — or I will say the body, in order to cover everything; the only source known to-day is the body of a person having typhoid fever and, of course, particularly his excrement. If the latter gets into drinking water it is a serious thing.

Mr. Holden. Mr. President, I would like to inquire why it is that usually there are relatively a small number of people who contract typhoid fever, in a town or city, using water from a contaminated reservoir?

Prof. Sedgwick. That is a very reasonable question and one that necessarily confronts anyone who looks at this matter dispassionately. Take that case of Plymouth, for example. There was an unques-

tionably polluted supply, and yet out of 8,000 people only 1,200 came down with typhoid fever. I say only 1,200; that is enough, perhaps, but how about the others? Why are not more attacked? The number attacked is generally less than one per cent of the population, though, in the case of Lowell, in 1890–91, there were, I believe, about 1,000 cases of typhoid fever in the city, in round numbers, out of 78,000 people living there at the time. Only one in seventy-eight came down with the disease. Why was this, when the water was presumably pretty thoroughly infected?

Well, in the first place, not every tumbler of water, of course, contains the germs. An infection means an almost infinite diffusion of small particles, yet not quite an infinite diffusion. These germs have size and weight. If anyone were to let into the Merrimac, for instance, at Nashua or Manchester, an almost unlimited number of embryo fishes as big as pins, by the time they got down to Lowell, if you dipped out a tumblerful of water you wouldn't get many of them. There is great dilution to begin with, and not every glass at such times, and perhaps not even every pitcherful, contains the germs.

In the second place, there are a number of people who don't drink any water. There are a good many children, for instance, little children, who are fed mainly on milk, and perhaps never take a drink of water, very young children, I mean. Then there are old men and old women who are sitting about and not doing much, who don't drink much water. Again, not all ages are susceptible.

And then, once more, after we have made all these deductions, it must be confessed that in the present state of our ignorance we don't know how many of the germs it takes to make an effective dose. I believe from what evidence there is that a good deal depends on the dose. I believe if I were to pass around here, for instance, a polluted water, infected water, if it was not too richly infected and I could persuade the members of the Association to take a drink of water, that a very considerable proportion would actually receive these germs without any bad effects. There is what physiologists call "vital resistance." Nobody knows much about it except that it exists. On a fine, bright morning, when a man has had a good rest and everything is just right, and when he feels, as he says, "Like a fighting cock;" when his tissues are in such a condition that he can do almost anything, when it would be dangerous for anyone to propose to knock a chip off his shoulder; at such a time I

believe that a man could take a moderate dose of these germs, or perhaps even a large dose, and come out unscathed. But on the other hand, there are times when a man feels, as he says, "Like a boiled owl," when he is "run down," "played out," "overworked," and has n't had a good night's rest; when the world is "using him wrong," and it is a "blue day," perhaps when his tissues are in a bad condition. We believe these to be actual physical conditions, when the blood and the tissues and the whole organism are not working up to the mark, and there is something wrong somewhere. At such a time I should be very sorry to give a man even one disease germ, because the chances are that he would come down with the disease.

And taking a community at large, with thousands of people, and making these various deductions, I believe the thing comes out just about as it ought to. We know that when the dose is big, as it was in the case of Plymouth, the results are big, and when the dose has in other cases been small, the results have been small. As a physiologist and bacteriologist I have never felt any serious difficulty in this direction. I believe the facts fit together and are about what we should expect, and that with a well regulated body we ought to be able to take in some disease germs and overcome them: but at other times, when we are run down, we should (and do) get into trouble.

One of the first things that a man who investigates a typhoid fever epidemic discovers is that in fifteen cases out of twenty, if he inquires, the victim had been complaining not only for the couple of weeks when he should have been complaining, but for many weeks before. It is the commonest kind of experience in such cases for people to say so. It is one of the questions I have on my blank, "How had he been in health before he was taken sick?" And the answer in fifteen cases out of twenty certainly, is, "Well, he had n't been well for a good many months, he had been working too hard and he was run down"; and people generally add, "the disease had been coming on for several months." Of course, the disease had not been coming on for several months, because the period of incubation, as we call it, is at the outside, probably, only three weeks from the time the germs are taken. But the point nevertheless was true. He had been run down for several months, when finally the germ happened to come along and caught him off guard,

so to speak. At the same time perhaps another germ may have struck his neighbor who was strong and well, the run-down man succumbing while the strong man went safely through the battle. It is just as it is in war. The strong and the well endure; the weak and the sickly perish. Armies lose more from sickness, you know, than from bullets, and we might say the same of the combatants with a typhoid infection.

Mr. RICHARDS. I think we owe Professor Sedgwick a debt of gratitude for the exceedingly practical way in which he has explained this matter. I would like to emphasize one point, and that is the danger from boating, which seems to me to be greater than any other danger, for this reason: the pollution from boats is likely to occur right at the in-take and we may then have, so to speak, a concentrated extract right at the point where it will do the most harm. I have recently had a good deal of opposition in trying to stop boating on our storage reservoir. I considered it a real danger, whereas the danger from pollutions from farm houses was, perhaps, more remote.

It seems to be customary to wait until an epidemic occurs and then engage a bacteriologist to tell what caused it. How much better it is to remove the cause before the epidemic occurs, by prohibiting all boating and fishing on reservoirs and by keeping the residents on the watershed as few in numbers and as far removed from the reservoirs as possible.

Mr. MCKENZIE. Of course the Professor knows, as well as any of us, that it is very easy to detect polluted water and ice supplies when the sources of pollution are numerous; but I would like to inquire if he knows of any State where they have laws by which Boards of Health, or other Boards, have judicial or mandatory powers to prevent such pollutions? Of course, in any State we can have made expensive chemical and bacteriological examinations of the water supplies, or we can discover in a practical way that they are polluted; but how are we going to prevent the pollutions? Now, in Connecticut, and I suppose in other States, efforts have been made to have laws enacted which would give the supervision of water supplies to some authority, either to Boards of Health, or to some other Boards which might be created for that purpose, but such attempts have always been defeated. Of course, there are vested rights in manufacturing properties, and there are sources of pollution which have been long continued, and which people claim they have a

right to continue; and without employing expensive attorneys and expensive specialists it is difficult to get any judicial decisions that will prevent such pollutions. What we want to know is how we can stop them.

Prof. SEDGWICK. Well, Mr. President, in Massachusetts, — I don't know about Connecticut, although it happens to be my native State, — in Massachusetts it is a very simple matter, because so far as managing the boating and fishing is concerned, — the vested rights I know nothing about, — any local board of health in Massachusetts can, by passing an ordinance, that such and such things shall not be done under penalty, make that the law, so that so much is very easily managed. With regard to vested rights, I suppose there is nothing to be done except to buy the owners out, and it is expensive. But I think one of the notions we have got to get over in water supply service is the idea that good water is cheap. We have grown up with that idea in this country, and it came from the time when we thought a stream purified itself by running a little distance. Lowell and Lawrence certainly would never have stuck their intake pipes down into the nearest stream, sewage polluted as it obviously was, if they had n't supposed they were to get fairly good water, very good water in fact; and Chicago would never have supplied the enormous number of gallons per capita that it does supply if it had supposed at the start that it had got to look out for a pure supply. Unfortunately science at that time was not far enough advanced for any one to know, and people believed that they were getting good water if it looked clear and tasted well. That led them to believe that they were entitled to any amount of good water for nothing, or next to nothing. As populations thicken, manufactories multiply, and the consumption of water increases, if it unfortunately does increase, we and they have got to get over that notion. People, communities, have got to learn that if they are going to have plenty of good water they have got to pay for it. They must either limit the quantity, or else the quality, as the country fills up. And I think an Association like this is doing and can do great work in stating these facts frankly and fully to the people. There are cases where chemical and bacteriological examinations do not necessarily help us very much. If you see sewage running right into a water supply you don't need any chemical examination or biological examination. We have learned to meet that more serious, more obvious problem, but I think the sooner it is

distinctly understood that good water, like everything good, is going to cost a good deal, the better for all concerned.

Mr. FULLER. Will Professor Sedgwick just say a word in regard to ice which is taken, we will say, from a pond which is fed by a stream which has a considerable population upon it. How much danger there is from such ice?

Prof. SEDGWICK. Well, of course, I can only make very general statements in regard to such a case. The State Board of Health made a careful examination of the ice supplies of this State a few years ago, and the results are published in full in one of the reports, I think for the year 1889. It was led to make it by the discovery of Professor Prudden of New York, that much of the ice supplied to New York City was so rich in bacteria, appearing to be hardly more than frozen sewage, that it constituted a real menace to the health of the people. The upshot of the investigations in Massachusetts was that there were very few, if any, really objectionable, or at least, dangerous, ice supplies; that ice does purify itself to a remarkable extent when produced under favorable conditions; but that if produced by chopping holes through a thin sheet of ice and allowing water to flow over and freeze up solid, or if it is full of bubbly or snowy ice, it may be objectionable.

I confess I have always felt that the case of New York was somewhat exaggerated. Professor Prudden is a very good friend of mine, and in saying this I do not reflect upon him at all. He is an admirable bacteriologist. But it seems to me his results proved a little too much. If the state of affairs was as bad as he said it was, New York City, instead of having one of the lowest typhoid death rates, should have had a pretty high one, and I have always thought the facts did not wholly fit his observations. But then, again, it must be remembered that that particular ice was very peculiar. It was cut on the Albany basin, that is on a tidal stream just below the city of Albany, where the Hudson River is highly polluted with the sewage of Albany and Troy, the Mohawk Valley and so forth, and it was made by chopping holes through the ice and allowing the water to flow on, and then freezing it up solid. In other words, it came pretty near being frozen sewage; as near, probably, as ice ever could be anywhere. And yet after that ice had been cut and delivered in New York, New York has had, and did have, and does still have, a remarkably low death rate from typhoid fever.

I personally am not much of a believer in the dangers from ice, but in any particular case I should want to know what the character of the stream coming in was; whether the ice was obtained by bathing the cakes in sewage which was allowed to run over their surface; whether, in fact, it was sewage; and a lot of details which could easily be looked up. But if it was cut at the other end from where the brook came in, so that it took a long time for the water to get there, and if the ice formed first in a thin layer and produced stillness so that sedimentation would go on below, and then was added to, little by little, *from below*, always by the freezing of the purest water, because sedimentation had taken place underneath, and without chopping holes and flowing the water over it, I should have no hesitation in using the ice. I tell my students if they ever get into any place where they cannot get any decent water and can get good ice, if they will take a piece of pure ice and melt it and drink it, they will probably have as good water as they can have without boiling it. I should certainly do that myself if I were placed under such circumstances.

Mr. DOANE. I would like to know as to the quality of ground water supplies, near polluted streams, particularly from filter basins, with only a comparatively thin wall of earth between, whether there would be a likelihood of the germs working through the sand for a short distance?

Prof. SEDGWICK. Of course, each case would require special investigation, and fortunately in this State we have a State Board of Health ready to make such investigations on requests from the proper authorities. But it seems to me that the experiments at Lawrence have shown very conclusively that a few feet of good filtering material are a wonderful safeguard. Of course what is good filtering material must be considered carefully in regard to any particular case, and the conditions must be known, and the question of sufficient ogygenation, etc., considered. In regard to a filter basin running alongside a stream, as a rule, that is supposed not to draw so much from the stream as from the shore side. It is more like a well of water. All I can say is, that I have been studying this matter for some time, and I have never yet seen any cases, such as were suggested, of contamination of that sort. And personally I am rather skeptical about the pollution of wells unless from the surface. If there is good filtering material at the bottom I believe it acts really as a good safeguard, and that the dangers from a ground supply are comparatively

small. At the same time it must be borne in mind that the Caterham case was a ground supply. That was a well supply, and the simple introduction of a human being with an intestine full of typhoid germs into that well was sufficient to make great trouble. But then there, also, the trouble came in from the top. And I believe that in all cases, or in nearly all cases, the trouble from wells, except, of course, where there is a fissure right through the ground, comes from washing in at the top and not from filtering through the soil.

The PRESIDENT. Most of us are well aware that there are other diseases besides typhoid fever that are directly attributable to our stomachs. I would like to ask Professor Sedgwick if there is not perhaps equal danger of contracting some of the other stomach diseases from bacilli from human excrement?

Prof. SEDGWICK. That, of course, Mr. President, is a very interesting question, and we have had some pretty good chances to study it in Lowell and Lawrence, in the past, and in many other places. I suppose the thing would be stated fairly about like this: That there is little or no evidence that diphtheria, scarlet fever, cholera infantum, smallpox, consumption, or any similar diseases are carried by water. They may all be so carried, theoretically, and if the water were to move quickly enough they would be, probably. For instance, if a diphtheritic patient should spit in my tumbler here, while he had his throat full of the germs, and I should drink the water right down, there would be a pretty good chance of my getting the disease. But hospitals have frequently drained into water supplies — hospitals containing the stuff from old sores and from stomachs and mouths and all that — and the facts seem to show, the figures seem to show, that about the only diseases that are much carried by water are typhoid fever, Asiatic cholera, dysentery, and diarrhœa. I think I have named them all. It is commonly stated as the diarrhœal diseases, but the trouble with that is it is a little too broad, because the diarrhœal diseases include cholera infantum, and we have no evidence, at least hereabouts, of cholera infantum being carried in water. It seems as if it ought to be, but it is not, so far as the facts indicate. And all we can say by way of explanation is that apparently the typhoid and Asiatic cholera germs and diarrhœa and dysentery germs are tougher than the rest, and will stand water better than the other germs.

You must remember that it is a pretty uncomfortable situation for

a thrifty, warm-blooded bacterium, like a typhoid germ, to find himself in, when he passes from a warm human intestine, with plenty of good rich matter to feed upon, down into a water supply such as you gentlemen have charge of, pure and clear as crystal. It is a cold world that he is received into, and he is given the cold shoulder. The temperature is away below that which he prefers. Food is scarce. He may perhaps find rivals in the diatoms and infusoria present; the infusoria often feed upon bacteria, and the first thing he knows he may be eaten up. But, if not, he has weight and he finds himself settling to the bottom, and getting tangled up in the water weeds there. Then, again, the light is antiseptic and hostile to him, and the first thing he knows there is too much light. He has been in a dark, warm chamber, the intestine, with rich food, richer than sewage, much richer, infinitely richer, to feed upon. He has been in the human sewer, which is so much richer than any city sewer in its contents that it makes a special feeding ground for these things. Now, imagine a bacterium taken out of this luxurious living, and put into the cold world, where the temperature is wrong, and food is scarce, and enemies are numerous, and troubles visit him on every hand. It appears to be only the tough ones who can stand it, and there is some evidence that the typhoid and Asiatic cholera germs are particularly tough. At any rate, so far as I know, the facts do not lead us to believe that there are many water-borne diseases other than those I have mentioned, at least in this latitude. For instance, there is no good evidence that malaria is conveyed by water, and yet possibly it may be. The only safe ground to take in these matters is that up to date our knowledge indicates about what I have suggested; but our knowledge, like railway time tables, is "subject to change without notice."

Mr. HAZEN. Mr. President, in this connection I would like to state in regard to cholera infantum (which is, of course, a subject about which I know nothing myself), that my friend, Dr. Reincke,* Health Commissioner of Hamburg, Germany, who has been studying this question for years, has come to the conclusion that cholera infantum is caused by bad water; and I have in my office quite a pile of German documents which show, by elaborate statistics, among other things, that cholera infantum is conveyed by water, and goes up

* Filtration of Public Water Supplies, page 144.

whenever typhoid goes up. Both have been reduced very much since the introduction of the filtered water supply in Hamburg, and not only have typhoid and cholera infantum decreased, but many other diseases have been decreased in a most surprising manner. The Doctor is unable to account for all of it, and he simply records the greatly decreased death rates as matters of fact.

PROCEEDINGS.

QUARTERLY MEETING.

YOUNG'S HOTEL,
BOSTON, Dec. 9, 1896.

President Haskell in the chair.

The following members and guests were present: —

ACTIVE MEMBERS.

Solon M. Allis, Geo. I. Bailey, Lewis M. Bancroft, Frank A. Barbour, George E. Batchelder, Oren B. Bates, Joseph E. Beals, James F. Bigelow, Forrest E. Bisbee, Gerald M. Bliss, George Bowers, John T. Cavanagh, George F. Chace, E. J. Chadbourne, Henry Chandler, John C. Chase, Harry W. Clark, Freeman C. Coffin, R. C. P. Coggeshall, H. W. Conant, Byron I. Cook, Henry A. Cook, John W. Crawford, A. O. Doane, Harrison P. Eddy, Loring N. Farnum, B. R. Felton, Charles R. Felton, F. F. Forbes, Frank L. Fuller, L. L. Gerry, Fred B. Gleason, Albert S. Glover, Frederick W. Gow, E. H. Gowing, John C. Haskell, V. C. Hastings, Arthur Elliot Hatch, George Mason Hawes, Allen Hazen, Horace G. Holden, Horatio N. Hyde, William S. Johnson, Willard Kent, Patrick Kieran, George A. Kimball, Morris Knowles, James W. Locke, Arthur J. L. Loretz, Cyrus M. Lunt, William J. Luther, Arthur D. Marble, Theodore H. McKenzie, William McNally, Thomas Naylor, Edward C. Nichols, Frank L. Northrop, Walter H. Richards, George J. Ries, W. W. Robertson, Harley E. Royce, A. H. Salisbury, William T. Sedgwick, John E. Smith, George A. Stacey, Frederic P. Stearns, Frederick L. Taylor, Lucian A. Taylor, Robert J. Thomas, D. N. Tower, Charles K. Walker, John C. Whitney, Geo. E. Wilde, G. E. Winslow, W. G. Zick.

HONORARY MEMBER.

"The Engineering Record," by C. J. Underwood.

ASSOCIATE MEMBERS.

Ashton Valve Company, by Mr. Dill.
Chapman Valve Manufacturing Company, by E. L. Ross.
Deane Steam Pump Company, by F. H. Hayes.
George E. Gilchrist, by H. N. Libbey.
Ludlow Manufacturing Company, H. F. Gould.

Michigan Brass and Iron Works, H. H. Kinsey.
Perrin, Seamans & Co., by Harold L. Bond.
Union Water Meter Company, by J. P. K. Otis and Geo. P. Carr.
R. D. Wood & Co., by Jesse Garrett.
The Geo. Woodman Company, by H. A. Gorham.
H. R. Worthington, by J. M. Betton and E. H. Foster.

GUESTS.

J. E. Bunting, C. H. Collins, A. Dunbar, J. L. Dwyer, A. Holman, Alex. McClurg, G. E. Putnam.

The Secretary read the following names of applicants for membership, recommended by the Executive Committee :—

RESIDENT ACTIVE.

John C. MacMurray, Worcester, Mass., President and General Manager of the Cherryvale Water Company, Cherryvale, Kan.
George Mason Hawes, Fall River, Civil and Mechanical Engineer.
Cyrus M. Lunt, Superintendent Water Works, Lewiston, Me.
Frank E. Merrill, Clerk, Somerville Water Board, Somerville, Mass.

NON-RESIDENT.

Arthur J. L. Loretz, M. E., Brooklyn, N. Y., Designer of Pumping Machinery.
Charles D. Bettes, Far Rockaway, L. I., Engineer in charge of Queen's County Water Company.

ASSOCIATE.

Charles A. Moore, New York City, Manufacturer of Steam Engines and Boiler Specialties and Iron Working Tools.
H. F. Gould, Boston, Mass., Ludlow Valve Manufacturing Company of Troy, N. Y.

On motion of Mr. Thomas, the Secretary was directed to cast the ballot of the Association in favor of the above-named applicants and they were declared elected members of the Association.

Prof. W. T. Sedgwick, of the Massachusetts Institute of Technology, addressed the Association on "The Protection of Surface Waters from Pollution." Messrs. Holden, Richards, McKenzie, Fuller, Doane, Hazen and the President participated in the discussion of the subject.

Arthur J. L. Loretz, M. E., of Brooklyn, N. Y., read a paper entitled "Pumping Engines."

Adjourned.

ADJOURNED MEETING.

YOUNG'S HOTEL,
BOSTON, Jan. 13, 1897.

President Haskell in the chair.

The following members and guests were present: —

ACTIVE MEMBERS.

Everett L. Abbott, Solon M. Allis, Charles H. Baldwin, Lewis M. Bancroft, George E. Batchelder, Oren B. Bates, James F. Bigelow, George Bowers, Dexter Brackett, James Burnie, George F. Chace, E. J. Chadbourne, John C. Chase, Harry W. Clark, Greeman C. Coffin, R. C. P. Coggeshall, H. W. Conant, Byron I. Cook, Henry A. Cook, F. H. Crandall, Lewis Cushing, Eben R. Dyer, Harrison P. Eddy, John W. Ellis, George E. Evans, B. R. Felton, F. F. Forbes, Frank L. Fuller, Julius C. Gilbert, Fred B. Gleason, T. C. Gleason, Albert S. Glover, J. A. Gould, Frederick W. Gow, John C. Haskell, Louis E. Hawes, T. G. Hazard, Jr., Allen Hazen, Horace G. Holden, Daniel D. Jackson, William S. Johnson, Willard Kent, Patrick Kieran, Frank C. Kimball, Morris Knowles, Perry Lawton, Wilbur F. Learned, James W. Locke, Arthur D. Marble, A. E. Martin, John C. MacMurray, Frank E. Merrill, Charles F. Murphy, Thomas Naylor, Frank L. Northrop, W. W. Robertson, A. H. Salisbury, William T. Sedgwick, George A. Stacey, Frederick P. Stearns, Frederick L. Taylor, Lucian A. Taylor, Robert J. Thomas, William H. Thomas, D. N. Tower, W. H. Vaughn, Charles K. Walker, J. Alfred Welch, John C. Whitney, George E. Winslow, E. T. Wiswall, W. G. Zick.

HONORARY MEMBERS.

"The Engineering Record," by C. J. Underwood, Jr.
"Fire and Water," by F. W. Shepperd.

ASSOCIATE MEMBERS.

Chadwick Lead Works, by A. H. Brodrick.
Chapman Valve Manufacturing Company, by E. L. Ross.
Deane Steam Pump Company, by F. H. Hayes.
Howe, S. G.
Ludlow Valve Manufacturing Company, H. F. Gould.
Michigan Brass and Iron Works, by H. H. Kinsey.
Thomson Meter Company, by S. D. Higley.
Union Water Meter Company, by J. P. K. Otis.
R. D. Wood & Co., by Jesse Garrett.
H. R. Worthington, by James M. Betton.

GUESTS.

J. D. Adams, T. E. Dwyer, F. E. Hunter, J. Edwin Jones, F. Pope, Geo. E. Putnam, Paul Sears, Thomas B. Tripp, Edmund Wood, Henry A. Wyman, Geo. D. Wemyss.

The Secretary read the following names of applicants for membership, recommended by the Executive Committee:

RESIDENT ACTIVE.

R. S. Bartlett, Superintendent Water Works, Norwich, Conn.
Edward I. Marvell, Civil Engineer, Fall River, Mass.

ASSOCIATE.

Solon G. Howe, Manufacturer Tapping Machines, Detroit, Mich.

On motion duly carried the Secretary was directed to cast the ballot of the Association for the above-named candidates, and they were declared elected members of the Association.

A call was then made by the President for volunteer five and ten-minute experience papers for the February and March meetings, and he stated that he thought there was not a superintendent there who had not had some experience that would be novel and of value to all the rest of the members.

Mr. WALKER. I have had an awful experience. [*Applause.*] Things don't run so smoothly with me as they might, but I do not want to tell you of my affliction. I don't know but I might have something for the meeting in March. Anything that I know, I got from these meetings here, and I am thankful for it; but I cannot give it back. [*Laughter.*]

Mr. STACEY. I suppose, Mr. Walker's experience is on water works and nothing else. I feel as he does. I have got a large amount of information since I joined this Association, and it seems to me as though all of us have something at stake here, in trying to keep up to the mark, and extend the knowledge that we have received from others, and I will say that I will do so in this matter. I find that in looking over the Journal the short experience papers we have had in the past, have interested me about as much as any. There is always meat in them, and they occur to us oftentimes when we are in a tight pinch and do help us out. So, Mr. President, I will try to do what I can to push the good thing along. [*Applause.*]

Mr. KIERAN. I likewise have learned a great deal from these meetings. If there is anything that I can give later on I will do so.

The PRESIDENT. I presume that in the course of a week or two you will all take the advice given by the Chair and send in notices of the titles of your papers. I know it is rather quick to think up all these experiences, but if you will send them in to us later, they will be just as acceptable.

The President then introduced Mr. Edmund Wood, member of the Water Board of New Bedford, who read a paper on the "Further Water Supply of the City of New Bedford, now being constructed." This paper was discussed by Mr. George E. Evans and many others. A paper was then read by Mr. Harry W. Clark, Chemist of the State Board of Health, on the "Removal of Iron from Ground Waters," which was discussed by Messrs. Hazen, Hawes and others. Mr. Stacey made the following remarks: —

THE VALUE OF WATER.

Mr. STACEY. There is a question I would like to ask. I ran up against an inquiry a while ago in regard to the financial part of water works management; as to whether it was a fair business way, or customary in making up the value of water works, to place any value on the water itself outside of the actual cost of construction. That is, saying that your water works cost you a certain sum of money in actual construction, and you have a supply sufficient for a city or town in the works, do you place any value on that water in making up the assets of the water works?

Mr. WHITNEY, Secretary. I can answer for the town of Newton at any rate, that they have never thought of taking water as an asset any more than the air that circulates through that vicinity.

The meeting then adjourned.

ADJOURNED MEETING.

YOUNG'S HOTEL,
BOSTON, Feb. 10, 1897.

President Haskell in the chair.

Members and guests were present as follows: —

ACTIVE.

Everett L. Abbott, Chas. H. Baldwin, Lewis M. Bancroft, Geo. E. Batchelder, Oren B. Bates, Joseph E. Beals, Jas. F. Bigelow, Geo. Bowers, Arthur W. F. Brown, John T. Cavanagh, Geo. F. Chace, Henry Chandler, R. C. P. Coggeshall, Byron I. Cook, Henry A. Cook, F. H. Crandall, Francis W. Dean, A. O. Doane, George E. Evans, A. A. Fobes, Frank L. Fuller, Julius C. Gilbert, Amos A. Gould, Albert S. Glover, Frank E. Hall, John C. Haskell, Louis E. Hawes, T. G. Hazard, Jr., Horace G. Holden, Willard Kent, Patrick Kieran, Geo. A. Kimball, Horace Kingman, Morris Knowles, Jas. W. Locke, Jas. W. Morse, Frank E. Merrill, Fred'k L. Rice, Walter H. Richards, George J. Ries, W. W. Robertson, Henry W. Rogers, A. H. Salisbury, John E. Smith, George A. Stacey, Lucian A. Taylor, Robert J. Thomas, D. N. Tower, W. H. Vaughn, Chas K. Walker, J. Alfred Welch, John C. Whitney, Geo. E. Winslow, E. T. Wiswall, W. G. Zick.

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Ludlow Valve Manufacturing Company, by H. F. Gould.
Michigan Brass and Iron Works, by H. H. Kinsey.
New York Filter Company, by Chas. Wilson.
Perrin, Seamans & Company, by H. L. Bond.
Thomson Meter Company, by Secretary Folger.
Union Water Meter Company, by J. P. K. Otis.
Walworth Manufacturing Company, by G. E. Pickering.
The George Woodman Company, by H. A. Gorham.
H. R. Worthington, by J. M. Betton.

GUESTS.

Mr. Bancroft, Mr. Gibson, Geo. L. Chapin, John F. Hurley, A. L. Estabrook.

The following applications for membership were recommended by the Executive Committee, and upon a vote were elected members of the Association: —

RESIDENT ACTIVE.

E. C. Brooks, Acting Superintendent, Cambridge, Mass.

Leonard Metcalf, Professor Engineering, Massachusetts Agricultural College, Amherst, Mass.

T. F. Richardson, Department Engineer, Metropolitan Water Board, Clinton, Mass.

C. H. Eglee, Constructing Engineer, Boston, Mass.

Frank M. Cole, Meter Inspector, Brockton, Mass.

LIBRARY.

The Secretary stated that endeavors were being made to form a library, and that an important portion of that library would consist of reports of city and town water works. He hoped that the members of the Association, in preparing their annual reports, would bear this in mind and favor the Association library with copies.

The President then introduced Mr. John Hurley, President of the Salem Water Board, who spoke as follows: —

REMARKS OF MR. JOHN HURLEY.

Mr. President and Gentlemen: I am somewhat surprised that your President should call upon me. I am not as competent or able to talk upon water supplies as others who are here. I have attended three or four meetings of this Association, and it has afforded me considerable pleasure to be present with you, gentlemen. It is a school of education that is beneficial to any man who is in any way interested in water supply. I have received these invitations from the Superintendent of the Salem Water Works, Mr. Cook, and I have always accepted them, for I knew that I could learn something by being present at the meetings that would be a benefit to the Board of which I am President, — the Salem Water Board.

At one of the first meetings that I attended, I listened to an address by Mr. Desmond FitzGerald, of Boston, who told of a dam that he was building. I became very much interested in what he said, not

knowing that I would ever be elected as a member of a water board, but my attention was directed forcibly to it.

At the table where I sat was Mr. Lucian A. Taylor, a member of your Association, and when a short time afterwards the Salem Water Board asked the city of Salem to appropriate for its use $74,000 for an additional water supply, the services of Mr. Taylor were secured as consulting engineer, and I assure you, gentlemen, that Salem made no mistake. We have, through the water supply of Wenham Lake, an abundance for our needs, and we have planned for a supply for Beverly, which is connected with us.

But there is something, gentlemen, which I wish to call your attention to. We have received from a gentleman, — I think it was the President of the Cambridge Water Board, — a letter asking us to cooperate with him in appearing before the Legislature to protest against out-houses and cesspools being built too near bodies of water used for water supply. Salem petitioned to the Legislature to make the distance limit five hundred feet in order to protect the water from pollution. Beverly, which is somewhat connected with Salem, opposed it, and Salem could do nothing. Our own stable at our pumping station was within one hundred feet of the lake, and we were compelled to move it some five hundred feet back. Within the last week typhoid fever has broken out, and the cesspool of the house where the typhoid fever now exists is not five hundred feet away, and there are cesspools within one hundred and fifty feet of the water supply. I think it would be well for every gentleman here to appear before the Committee on Water Supply at the State House and protest and do what can be done to do away with all out-houses and cesspools within five hundred feet of lakes used for water supply.

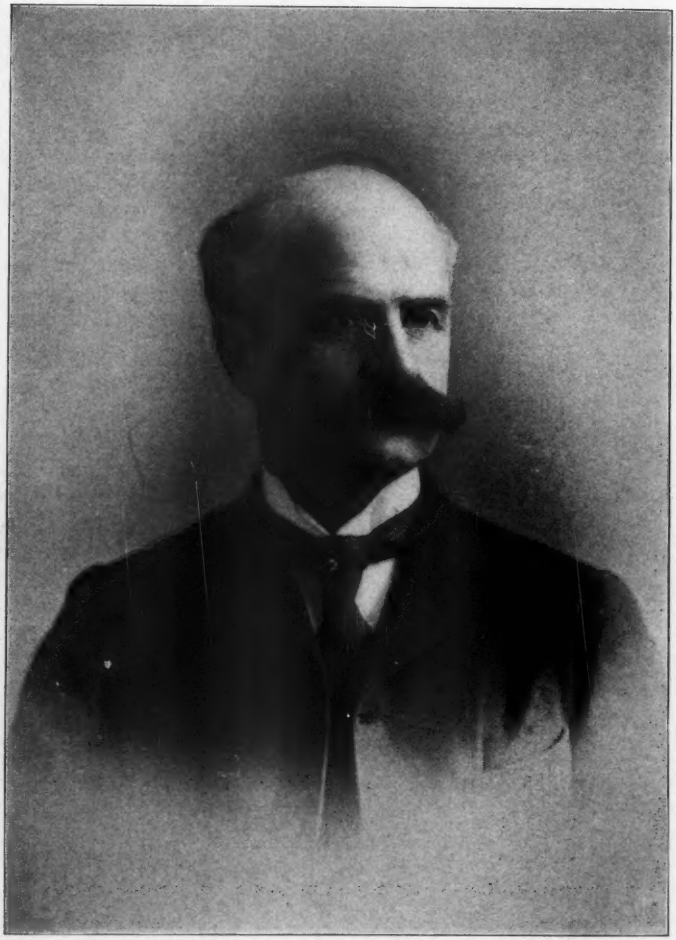
Typhoid fever, before the introduction of water from Wenham Lake, was quite prevalent. We had forty-eight cases at one time, but since we have had our new supply there has not been a solitary case of typhoid fever in Salem.

We have had quite a controversy in Salem in regard to diphtheria. We have had forty-two cases. Of course it is not caused by the water, but in the forty-two cases that we have in Salem to-day there is not one left-handed child who has got the diphtheria, which is accounted for from the fact that they drink with the left hand and therefore drink from the other side of the dipper from what the right-handed children drink, so that they do not contract the disease from the right-handed children. [*Laughter.*]

Mr. Stacey of Marlboro, Mr. Walker of Manchester, Mr. Crandall of Burlington, Mr. F. L. Fuller of Boston, and Mr. Hawes of Boston then presented experience papers which were discussed.

Mr. Allis gave an interesting account of the breaking of pipes in winter in Malden. He decided to have them break at a more convenient season. The pipe was weak in places, and extra pressure at times was too much for it. Accordingly, at a convenient time in good weather, the pressure was raised considerable, and numerous breaks resulted. These were repaired at one fifth of the cost of repairing in winter. During the following winter care was exercised to avoid high pressure, and there were no breaks.

The meeting then adjourned.



ALBERT FRANKLIN NOYES,

Past President of the

NEW ENGLAND WATER WORKS ASSOCIATION.

Died October 12, 1896.

Obituary.

James Hugh Stanwood, died May 25, 1896, aged 34 years. Joined the Association June 15, 1894.

Mr. Stanwood was a native of Maine, a graduate of the Massachusetts Institute of Technology in the class of 1887, and instructor of civil engineering in that school. He was a member of the Boston Society of Civil Engineers, and an associate member of the American Society of Civil Engineers.

Ezra Clark, died Sept. 26, 1896, aged 82 years. Joined the Association Dec. 14, 1887.

Mr. Clark had been President of the Hartford Water Board for sixteen years, during which time the work of building the reservoirs and system was largely accomplished. The Tumbledown Brook reservoir was first suggested and urged by Mr. Clark, and the reservoir park was also his planning.

Mr. Clark was a member of Congress from 1855 to 1859, and was always prominent in public affairs.

William E. Nason, died Oct. 10, 1896. Joined the Association June 16, 1886.

Mr. Nason was a veteran of the Civil War, and was instrumental in the construction of the water works of Franklin, N. H., of which he afterwards became Superintendent and had charge of at the time of his death.

Albert F. Noyes, died Oct. 12, 1896, aged 45 years. Joined the Association Dec. 3, 1884.

Mr. Noyes was one of the first to join the Association after its formation. He was a member of the Executive Committee, 1887–8, and was President, 1890–1. He presented papers which have been published by the Association, as follows: "Weight of Cast Iron Pipe," 1885, 154; "Driven Wells as a Means of Water Supply," Vol. I., 4; "Experience in Excavating in Quicksand," Vol. IV.,

218; "The Metropolitan Water Supply of Massachusetts," Vol. X., 117; also the President's annual address, Vol. VI., 5.

Mr. Noyes was a member of the Boston Society of Civil Engineers, which he served as Vice-President and afterward as President; of the Massachusetts Highway Association, of which he was Vice-President; of the American Society of Civil Engineers, and of the American Public Health Association. For seventeen years, ending in 1893, Mr. Noyes was City Engineer of Newton, and as such had much to do with the extensions and improvements of the Newton water works. Afterwards for two years he was Assistant Chief Engineer of the Massachusetts State Board of Health, and at the time of his death he was in private practice as consulting engineer, making a specialty of water works matters. He was also an alderman of Newton, and a member of the Metropolitan Sewerage Commission.

Mr. Noyes was a constant attendant of the meetings of the Association, and was ready to take part in the discussions and to help the work in any way. His straightforward honesty and good will made him a universal favorite, not only with the members of the Association, but with all who knew him; while his advice upon the most varied subjects was sought and prized because of his wide experience, close observation and sound common sense, and because it was always given freely and gladly and with an unselfishness which could be influenced by nothing but the best interests of those who sought his counsel.

Wilmer Reed, died November, 1896. Joined as an associate member January 8, 1890.

Mr. Reed was selling agent for the McNeal Pipe and Foundry Company, and was well known to the members.

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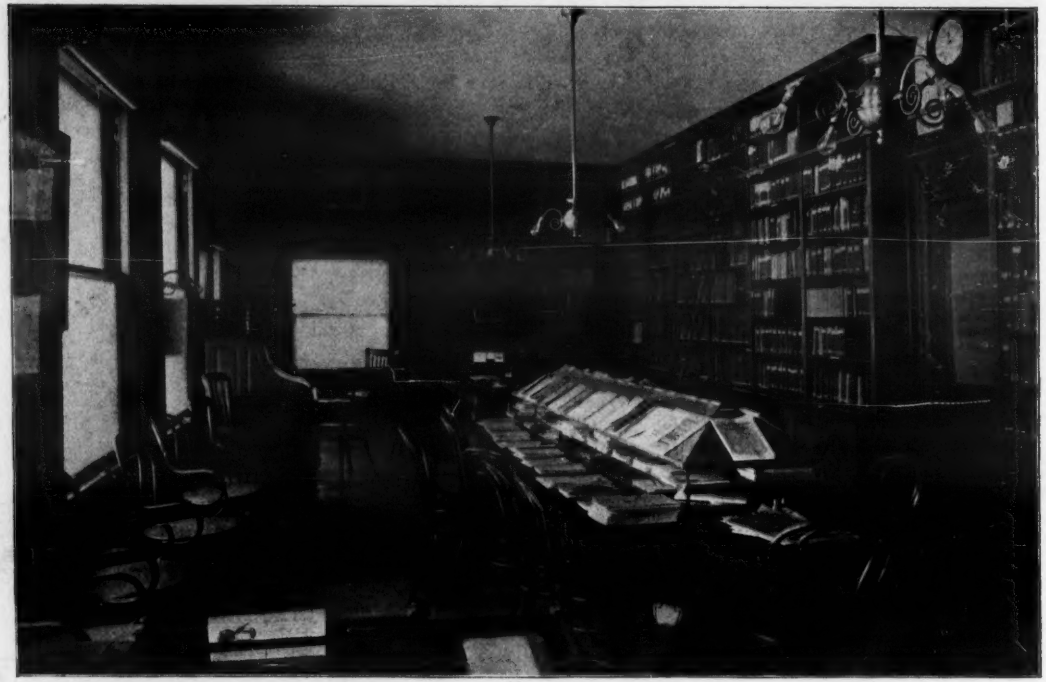

HEADQUARTERS OF THE ASSOCIATION—TREMONT TEMPLE BUILDING, BOSTON.